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FREE-BOUND RADIATION FROM NITROGEN, OXYGEN, AND AIR

M. P. SHERMAN
J. L. KULANDER

SPACE SCIENCES LABORATORY

MISSILE AND SPACE DIVISION

GENERAL ELECTRIC

SPACE SCIENCES LABORATORY
THEORETICAL FLUID PHYSICS SECTION

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By

M. P. Sherman
J. L. Kulander

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SUMMARY

Photoabsorption cross sections for nitrogen and oxygen atoms are computed using the Method of Burgess and Seaton [2]. Results are presented for the radiative recombination of singly ionized nitrogen and oxygen applicable for equilibrium air, for chemical nonequilibrium with internal equilibrium, and internal nonequilibrium.

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LIST OF SYMBOLS

A = Angstrom unit

B = Total equilibrium intensity

B_ν = Equilibrium intensity per unit frequency interval

c = Speed of light

E = Electron kinetic energy

ΔE_{ij} = Energy difference between state j of the ion and state i of the atom

f_e = Electron distribution function - assumed Maxwellian

h = Planck constant

k = Boltzmann constant

K_ν = Equilibrium spectral absorption coefficient

$K_{\nu s}$ = s species contribution to spectral absorption coefficient

K_P = Equilibrium Planck mean absorption coefficient

K_{Ps} = s species contribution to Planck mean absorption coefficient

m_e = Election mass

n_p = Photon density per unit frequency interval

n_s = Particle density of species s

n_{si} = Particle density of energy level i of species s

T = Temperature

ϵ = Rate of spontaneous emission per unit volume

ϵ_ν = Rate of spontaneous emission per unit volume per unit frequency interval

γ = Wavelength

ν = Frequency

$\bar{\sigma}_s$ = Mean absorption cross section of species s at frequency ν

σ_{sij} = Photoabsorption cross section for a transition from state i of the atom s to state j of the ion a frequency ν

σ^{+}_{sij} = Radiative recombination cross section for a transition from state j of the ion s^{+} to state i of the atom for an electron energy corresponding to emission of frequency ν

φ^{+}_{sji} = Quantity related to the stimulated emission of frequency ν from an ion of species s^{+}

ω_s Statistical weight of energy level i of species s

INTRODUCTION

This report considers the absorption of radiation due to the photoionization of nitrogen and oxygen atoms, and the reverse process, the radiative recombination of singly ionized nitrogen and oxygen ions with electrons. Eighteen allowed radiative transitions between states of the atom and ion were considered for the nitrogen and twelve for the oxygen. This list of transitions can be found in Tables I and II.

The radiative recombination of singly ionized nitrogen and oxygen ions with electrons will be the principal source of radiation from air in the temperature range of ten to fifteen thousand degrees Kelvin. Other processes which contribute to the radiation are free-free radiative transitions (Bremsstrahlung), atomic line radiation, molecular bound-bound transitions, and radiative recombination of molecular ions and negative ions.

Results are presented for three possible conditions of nonequilibrium. If the population of the internal states concerned with the emission and possibly the absorption of radiation are not in a Boltzmann equilibrium distribution it is necessary to explicitly consider each radiative transition. If the internal states are in a Boltzmann distribution and the mole fractions of the various species are in equilibrium then the spontaneous emission of radiation per unit volume will be the equilibrium value. This is true whether the radiant intensity is the equilibrium value or if it is not, as in an optically thin gas. In this case it is possible to sum over all the

transitions of all the species and obtain an absorption coefficient for the gas and a corresponding rate of emission. There is a third possibility. The internal states may be in a Boltzmann distribution, but the mole fractions of the chemical species may be far from equilibrium. In this case it is possible to sum over all transitions involving a given species, but one can not add these results to obtain a value for the gas without knowing the composition of the gas.

As long as the gas is not in complete thermodynamic equilibrium, the material particles and the radiation, one can not expect to find the chemical composition or the internal distribution function to be in equilibrium because of the failure of the detailed balancing of individual processes. However, if the collisional processes are dominant the chemical composition and internal distribution can be very near equilibrium even if the radiation is not in equilibrium. Kulander (1) has shown for nitrogen and presumably for oxygen that there is a wide domain in which the internal states are near equilibrium even though the chemical composition and radiation are far from equilibrium. This results from the fact that the lower lying levels in N and O, which are the only levels significantly populated for the temperatures under consideration, do not have any allowed radiative transitions between them. Hence, the two partial equilibrium conditions considered do approximate many real situations.

If the absorption of radiation is negligible, as for an optically thin gas with small background radiation, then for internal and chemical equilibrium it is useful to integrate the absorption coefficient over the spectrum and obtain the Planck mean absorption coefficient. The total rate of emission per unit volume is then easily obtained. A slight generalization of these results permits application to the case of chemical nonequilibrium but internal equilibrium.

CALCULATION OF THE PHOTOIONIZATION CROSS SECTION

The photoionization cross sections are calculated using the "quantum defect" method of Burgess and Seaton (2). This method utilizes the empirically known energies of the bound atomic states to obtain the correct asymptotic forms for the bound and free wave functions. In other respects the wave function calculations are based on a central field approximation. The method obviously fails if no known energy levels are available. Further, since the wave functions are only approximate, their positive and negative contributions in obtaining the matrix elements sometimes cancel severely, yielding a near zero cross section. When this occurs, the result is described as highly sensitive and is of low accuracy. In frequency regimes where the sensitivity is high a hydrogenic value is fitted to the quantum defect result. Such problems affect about 30% of the cross sections at one frequency or another. An example of the procedures used is shown in Fig. 1.

SPONTANEOUS AND STIMULATED EMISSION

The spontaneous emission cross section and the stimulated emission are obtained from the photoionization cross section by detailed balancing at equilibrium. The volumetric rate of absorption for a given transition by a photon in frequency interval $d\nu$ is,

1) $$n_s \sigma_{sij} c n_p d\nu$$

while the corresponding rate of spontaneous and stimulated emission is,

2) $$f_e n_s^+ \left[\frac{2E}{m_e}\right]^{1/2} \left\{\sigma_{sji}^+ + n_p \varphi_{sji}^+\right\} h d\nu$$

At equilibrium the photon density is

3) $$n_p = \frac{8\pi\nu^2}{c^3} \left[\exp(h\nu/kT) - 1\right]^{-1}$$

Equating absorption and emission we find

4) $$\sigma_{sij} = \frac{2\omega_s^+}{\omega_s} \frac{m_e c^2}{\nu^2 h^2} E \sigma_{sji}^+$$

5) $$\sigma_{sji}^+ = \frac{8\pi\nu^2}{c^3} \varphi_{sji}^+$$

INTERNAL AND CHEMICAL EQUILIBRIUM

The mean absorption cross section per particle of species s is,

6) $$\bar{\sigma}_s = \sum_i \sum_j \frac{n_{si}}{n_s} \sigma_{sij}$$

where the summation is carried over all significant transitions for which

7) $$E = h\nu - \Delta E_{ij} \geq 0$$

A graph of $\bar{\sigma}_s$ versus frequency will have jumps or "edges" at frequencies where additional terms enter the summation. The absorption coefficient including stimulated emission is defined

8) $$K_\nu = \sum_s n_s \bar{\sigma}_s \left[1-\exp(-h\nu/kT)\right]$$

The rate of emission is

9) $$\epsilon_\nu = 4\pi K_\nu B_\nu$$

10) $$\text{where } B_\nu = \frac{2h\nu^3}{c^2} \left[\exp(h\nu/kT) - 1\right]$$

Integrating over frequency

11) $$\epsilon = \int_0^\infty \epsilon_\nu d\nu = 4\pi B K_P$$

12) $$K_P = \frac{\int_0^\infty K_\nu B_\nu \, d\nu}{B}$$

13) $$B = \int_0^\infty B_\nu \, d\nu$$

INTERNAL EQUILIBRIUM AND CHEMICAL NONEQUILIBRIUM

The following relations are readily obtained from eqs. 1-7. The mean absorption cross section per particle is defined as before. The absorption coefficient including stimulated emission is

14) $$K_\nu = \sum_s n_s \bar{\sigma}_s \left[1 - F_s \exp(-h\nu/kT) \right]$$

where

15) $$F_s = \left(\frac{n_s + n_e}{n_s} \right) \Big/ \left(\frac{n_s + n_e}{n_s} \right)_{eq.}$$

The subscript eq. indicates equilibrium value.

The spontaneous emission is

$$16)\qquad \epsilon_\nu = 4\pi B_\nu \sum_s F_s n_s \bar{\sigma}_s \left[1-\exp\left(-h\nu/kT\right)\right]$$

$$= 4\pi B_\nu \Sigma F_s K_{\nu s}$$

where we have defined species absorption coefficients .

$$17)\qquad K_{\nu s} = n_s \bar{\sigma}_s \left[1-\exp\left(h\nu/kT\right]\right.$$

We can integrate each species over frequency to obtain species Planck mean absorption coefficients.

$$18)\qquad K_{Ps} = \int_0^\infty B_\nu K_{\nu s}\, d\nu \Big/ B$$

$$19)\qquad \epsilon = 4\pi B \sum_s F_s K_{Ps}$$

Note that at chemical equilibrium as the F_s equal unity and the formulas become identical to those of the previous section.

PRESENTATION OF THE RESULTS

Since the various cross section are functions of frequency and temperature it is not practical to present all the results in graphical form. The figures used are for illustrative purposes. The tables present sufficient data so that more detailed graphs can be made and interpolation can be used. It is possible to use tables since the curves can be adequately described by the values at the edges and just before the edges.

The results are presented using three significant figures. However, the results are obtained from initial calculations of the photoionization cross sections which may be in error by as much as 50%.

For internal nonequilibrium the individual transition photoionization cross sections are presented. For internal equilibrium and chemical nonequilibrium the mean absorption coefficient per nitrogen and per oxygen atom are given. These are integrated over frequency to give Planck mean absorption coefficient per nitrogen and oxygen atom. For internal and chemical equilibrium the absorption coefficient is given. This is integrated over frequency to obtain total emission per unit volume.

The results are presented as functions of wave number. The relation between wavenumber (cm^{-1}), frequency (sec^{-1}), wavelength (cm), and wavelength (A) is

$$\begin{aligned} \text{wave number} &= \nu / c \\ &= 1/\lambda \\ &= 10^8/A \end{aligned}$$

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TABLE I

NITROGEN LEVELS AND TRANSITIONS

	Level No.	Spectroscopic Designation	Mean energy above G.S. of Atom (cm^{-1})	Degeneracy	Transitions Atom → ion	ΔE (cm^{-1})
N						
	1	^4S	0	4	1-1	117, 345
	2	^2D	19, 226	10	2-2	98, 118
					2-1	113, 434
	3	^2P	28, 840	6	3-3	88, 505
					3-2	103, 821
					3-1	121, 198
	4	^4P	83, 320	12	4-1	34, 026
	5	^2P	86, 200	6	5-1	31, 165
	6	^4P	88, 140	12	6-7	73, 360
					6-6	121, 442
					6-5	138, 413
					6-4	184, 322
	7	^2S	93, 582	2	7-1	23, 763
	8	^4D	94, 830	20	8-1	22, 545
	9	^4P	95, 500	12	9-1	21, 845
	10	^4S	96, 752	4	10-1	20, 593
	11	^2D	96, 820	10	11-1	20, 525
	12	^2D	97, 790	6	12-1	19, 563
N^+						
	1	^3P	117, 345	9		
	2	^1D	132, 661	5		
	3	^1S	150, 038	1		
	4	^5S	161, 513	5		
	5	^3D	209, 545	15		
	6	^3P	226, 566	9		
	7	^1D	272, 475	5		

TABLE II

OXYGEN LEVELS AND TRANSITIONS

	Level No.	Spectroscopic Designation	Mean energy above G. S. of Atom (cm^{-1})	Degeneracy	Transitions Atom → ion	ΔE
O						
	1	^3P	0	9	1-1	109, 837
					1-2	136, 656
					1-3	150, 304
	2	^1D	15, 868	5	2-2	120, 788
					2-3	134, 436
	3	^1S	33, 792	1	3-3	116, 512
	4	^5S	73, 768	5	4-1	36, 069
	5	^3S	76, 795	3	5-1	33, 042
	6	^5P	86, 627	15	6-1	23, 210
	7	^3P	88, 630	9	7-1	21, 202
	8	^5S	95, 476	5	8-1	14, 361
	9	^3S	96, 226	3	9-1	13, 611
O^+						
	1	^4S	109, 837	4		
	2	^2D	136, 656	10		
	3	^2P	150, 304	6		

TABLE III

NITROGEN ATOM PHOTOIONIZATION CROSS SECTIONS

		CROSS SECTION (cm^2)							
cm^{-1}	A°	12-1	11-1	10-1	9-1	8-1	7-1	5-1	4-1
19563.	5111.69	0.239-17*	0.	0.	0.	0.	0.	0.	0.
20525.	4872.11	0.246-17	0.320-17	0.	0.	0.	0.	0.	0.
20593.	4856.02	0.247-17	0.302-17	0.589-17	0.	0.	0.	0.	0.
21845.	4577.71	0.254-17	0.306-17	0.528-17	0.294-17	0.	0.	0.	0.
22545.	4435.57	0.256-17	0.307-17	0.496-17	0.250-17	0.439-17	0.	0.	0.
23763.	4208.22	0.257-17	0.306-17	0.447-17	0.190-17	0.345-17	0.291-17	0.	0.
31165.	3208.73	0.233-17	0.269-17	0.231-17	0.111-17	0.111-17	0.161-17	0.148-17	0.
34026.	2938.93	0.217-17	0.249-17	0.174-17	0.952-18	0.956-17	0.136-17	0.154-17	0.659-17
73360.	1363.14	0.718-18	0.801-18	0.288-18	0.147-18	0.195-18	0.218-18	0.887-18	0.192-17
88505.	1129.88	0.503-18	0.558-18	0.231-18	0.132-18	0.101-18	0.184-18	0.676-18	0.133-17
98118.	1019.18	0.411-18	0.454-18	0.200-18	0.120-18	0.848-19	0.164-18	0.574-18	0.108-17
103821.	963.20	0.366-18	0.405-18	0.184-18	0.113-18	0.810-19	0.153-18	0.523-18	0.963-18
113434.	881.57	0.306-18	0.337-18	0.160-18	0.102-18	0.746-19	0.136-18	0.450-18	0.801-18
117345.	825.19	0.285-18	0.314-18	0.152-18	0.979-19	0.720-19	0.130-18	0.424-18	0.746-18
121198.	825.10	0.266-18	0.293-18	0.144-18	0.938-19	0.695-19	0.124-18	0.401-18	0.697-18
121442.	823.44	0.265-18	0.292-18	0.143-18	0.936-19	0.694-19	0.124-18	0.399-18	0.694-18
138413.	722.48	0.201-18	0.221-18	0.114-18	0.778-19	0.592-19	0.102-18	0.315-18	0.525-18
184322.	542.53	0.108-18	0.118-18	0.674-19	0.489-19	0.389-19	0.628-19	0.183-18	0.281-18
200000.	500.00	0.904-19	0.985-19	0.575-19	0.424-19	0.340-19	0.541-19	0.156-18	0.235-18

*.993-17 is $.993 \times 10^{-17}$

CROSS SECTION (cm^2)

6-4	3-1	2-1	3-2	2-2	1-1	3-3	6-5	6-6	6-7
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.993-17	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.842-17	0.705-17	0.	0.	0.	0.	0.	0.	0.	0.
0.718-17	0.673-17	0.339-17	0.	0.	0.	0.	0.	0.	0.
0.648-17	0.637-17	0.326-17	0.322-17	0.	0.	0.	0.	0.	0.
0.543-17	0.564-17	0.293-17	0.302-17	0.231-17	0.	0.	0.	0.	0.
0.505-17	0.533-17	0.278-17	0.290-17	0.231-17	0.848-17	0.	0.	0.	0.
0.470-17	0.504-17	0.263-17	0.277-17	0.228-17	0.878-17	0.141-17	0.	0.	0.
0.468-17	0.502-17	0.262-17	0.276-17	0.228-17	0.879-17	0.141-17	0.192-17	0.	0.
0.344-17	0.385-17	0.200-17	0.217-17	0.199-17	0.865-17	0.141-17	0.212-17	0.995-18	0.
0.163-17	0.192-17	0.964-18	0.105-17	0.112-17	0.525-17	0.861-18	0.135-17	0.118-17	0.979-18
0.130-17	0.154-17	0.766-18	0.837-18	0.918-18	0.429-17	0.703-18	0.110-17	0.102-17	0.989-18

TABLE IV

OXYGEN ATOM PHOTOIONIZATION CROSS SECTIONS

(CROSS SECTION-cm^2)

TRANSITIONS

cm^{-1}	A^o	9-1	8-1	7-1	6-1	5-1	4-1	1-1	3-3	2-2	2-3	1-2	1-3
13611.	7347.00	0.928-18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14361.	6963.30	0.903-18	0.874-18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21207.	4715.42	0.660-18	0.726-18	0.638-17	0.	0.	0.	0.	0.	0.	0.	0.	0.
23210.	4308.49	0.598-18	0.676-18	0.536-17	0.463-17	0.	0.	0.	0.	0.	0.	0.	0.
33042.	3026.45	0.378-18	0.470-18	0.235-17	0.123-17	0.533-18	0.	0.	0.	0.	0.	0.	0.
36069.	2772.46	0.332-18	0.421-18	0.178-17	0.105-17	0.552-18	0.523-18	0.	0.	0.	0.	0.	0.
109837.	910.44	0.414-19	0.678-19	0.195-18	0.877-19	0.185-18	0.208-18	0.352-17	0.	0.	0.	0.	0.
116516.	858.25	0.365-19	0.606-19	0.177-18	0.819-19	0.167-18	0.189-18	0.353-17	0.864-17	0.	0.	0.	0.
120788.	827.90	0.338-19	0.565-19	0.167-18	0.784-19	0.157-18	0.178-18	0.346-17	0.916-17	0.825-17	0.	0.	0.
134436.	743.85	0.268-19	0.458-19	0.139-18	0.682-19	0.130-18	0.147-18	0.306-17	0.943-17	0.843-17	0.134-17	0.	0.
136656.	731.76	0.259-19	0.444-19	0.135-18	0.667-19	0.126-18	0.143-18	0.298-17	0.934-17	0.835-17	0.140-17	0.222-17	0.
150304.	665.32	0.210-19	0.367-19	0.113-18	0.581-19	0.106-18	0.120-18	0.248-17	0.839-17	0.748-17	0.159-17	0.261-17	0.112-17
180000.	555.56	0.141-19	0.256-19	0.810-19	0.438-19	0.752-19	0.858-19	0.160-17	0.580-17	0.517-17	0.136-17	0.236-17	0.133-17
200000.	500.00	0.111-19	0.206-19	0.659-19	0.367-19	0.612-19	0.698-19	0.119-17	0.439-17	0.393-17	0.109-17	0.195-17	0.117-17

TABLE V. MEAN ABSORPTION COEFFICIENT PER NITROGEN ATOM

cm^{-1}	Å	Temperature in °K 6000	8000	1000	12000	14000	16000	18000	20000
19500.	5128.21	0	0	0	0	0	0	0	0
19563.	5111.69	.229-27	.742-25	.222-23	.203-22	.945-22	.289-21	.673-21	.129-20
20500.	4878.05	.236-27	.770-25	.231-23	.212-22	.989-22	.303-21	.708-21	.136-20
20525.	4872.11	.846-27	.264-24	.776-23	.699.22	.322-21	.981-21	.227-20	.436-20
20593.	4856.02	.133-26	.412-24	.120-22	.108-21	.498-21	.151-20	.350-20	.672-20
21800.	4587.16	.129-26	.403-24	.118-22	.107-21	.493-21	.150-20	.349-20	.672-20
21845.	4577.71	.227-26	.681-24	.196-22	.174-21	.797-21	.241-20	.557-20	.106-19
22500.	4444.44	.211-26	.637-24	.184-22	.164-21	.752-21	.228-20	.528-20	.101-19
22545.	4435.57	.499-26	.142-23	.397-22	.347-21	.156-20	.470-20	.108-19	.205-19
23700.	4219.41	.417-26	.120-23	.337-22	.296-21	.134-20	.405-20	.932-20	.177-19
23763.	4208.22	.439-26	.125-23	.351-22	.308-21	.139-20	.420-20	.966-20	.184-19
31100.	3215.43	.221-26	.652-24	.187-22	.168-21	.777-21	.238-20	.557-20	.107-19
31165.	3208.73	.452-26	.103-23	.264-22	.222-21	.989-21	.295-20	.678-20	.129-19
34000.	2941.18	.433-26	.965-24	.244-22	.205-21	.911-21	.272-20	.626-20	.119-19
34026.	2938.93	.451-25	.663-23	.128-21	.895-21	.348-20	.946-20	.202-19	.364-19
73000.	1369.86	.138-25	.203-23	.394-22	.276-21	.108-20	.299-20	.648-20	.119-19
73360.	1363.14	.330-25	.561-23	.117-21	.866-21	.351-20	.985-20	.216-19	.401-19
88000.	1136.36	.262-25	.450-23	.949-22	.701-21	.285-20	.800-20	.176-19	.327-19
88505.	1129.88	.102-19	.545-19	.141-18	.257-18	.386-18	.514-18	.637-18	.751-18
98000.	1020.41	.980-20	.521-19	.135-18	.246-18	.369-18	.491-18	.607-18	.715-18
98118.	1019.18	.921-19	.298-18	.587-18	.898-18	.119-17	.145-17	.167-17	.186-17
103000.	970.87	.891-19	.288-18	.567-18	.867-18	.115-17	.140-17	.161-17	.179-17
103821.	963.20	.932-19	.311-18	.627-18	.978-18	.131-17	.162-17	.188-17	.211-17
113000.	884.96	.843-19	.281-18	.568-18	.886-18	.119-17	.147-17	.171-17	.191-17
113434.	881.57	.140-18	.448-18	.874-18	.132-17	.175-17	.212-17	.243-17	.269-17
117000.	854.70	.136-18	.435-18	.848-18	.128-17	.696-17	.205-17	.235-17	.260-17
117345.	852.19	.840-17	.824-17	.803-17	.782-17	.764-17	.748-17	.733-17	.719-17
121000.	826.45	.868-17	.848-17	.824-17	.799-17	.777-17	.758-17	.741-17	.724-17
121198.	825.10	.869-17	.850-17	.828-17	.805-17	.786-17	.769-17	.753-17	.739-17
121442.	823.44	.870-17	.852-17	.828-17	.806-17	.786-17	.769-17	.754-17	.740-17
138000.	724.64	.856-17	.833-17	.803-17	.773-17	.747-17	.724-17	.704-17	.685-17
138413.	722.48	.854-17	.830-17	.801-17	.771-17	.745-17	.722-17	.701-17	.683-17
184000.	543.48	.519-17	.503-17	.482-17	.461-17	.442-17	.425-17	.410-17	.397-17
184322.	542.53	.517-17	.501-17	.480-17	.459-17	.440-17	.423-17	.409-17	.396-17
200000.	500.00	.423-17	.409-17	.392-17	.374-17	.359-17	.345-17	.333-17	.323-17

TABLE VI. MEAN ABSORPTION COEFFICIENT PER OXYGEN ATOM

cm^{-1}	Å	Temperature in °K							
		6000.	8000.	10000.	12000.	14000.	16000.	18000.	20000.
13600.	7352.94	0	0	0	0	0	0	0	0
13611.	7347.00	.282-28	.840-26	.245-24	.224-23	.106-22	.335-22	.803-22	.159-21
14300.	6993.01	.227-28	.828-26	.242-24	.223-23	.106-22	.335-22	.805-22	.160-21
14361.	6963.30	.810-28	.235-25	.679-24	.617-23	.291-22	.913-22	.218-21	.432-21
21200.	4716.98	.663-28	.198-25	.589-24	.550-23	.266-22	.852-22	.207-21	.417-21
21207.	4715.42	.378-26	.747-24	.173-22	.137-21	.591-21	.173-20	.395-20	.753-20
23200.	4310.34	.319-26	.634-24	.148-22	.118-21	.511-21	.151-20	.345-20	.661-20
23210.	4308.49	.104-25	.190-23	.421-22	.325-21	.137-20	.387-20	.895-20	.169-19
33000.	3030.30	.338-26	.631-24	.143-22	.113-21	.491-21	.145-20	.334-20	.644-20
33042.	3026.45	.515-26	.803-24	.169-22	.129-21	.547-21	.159-20	.364-20	.696-20
36000.	2777.78	.460-26	.695-24	.144-22	.109-21	.463-21	.135-20	.308-20	.590-20
36069.	2772.46	.106-25	.118-23	.211-22	.147-21	.591-21	.167-20	.371-20	.699-20
109000.	917.43	.331-26	.308-24	.482-23	.306-22	.115-21	.313-21	.680-21	.126-20
109837.	910.44	.348-17	.341-17	.333-17	.325-17	.317-17	.309-17	.301-17	.294-17
116000.	862.07	.349-17	.343-17	.334-17	.326-17	.318-17	.310-17	.303-17	.295-17
116516.	858.25	.349-17	.342-17	.335-17	.327-17	.320-17	.314-17	.308-17	.302-17
120000.	833.33	.344-17	.337-17	.330-17	.322-17	.315-17	.309-17	.304-17	.298-17
120788.	827.90	.352-17	.361-17	.373-17	.384-17	.395-17	.404-17	.413-17	.419-17
134000.	746.27	.314-17	.324-17	.337-17	.349-17	.361-17	.372-17	.382-17	.390-17
134436.	743.85	.314-17	.327-17	.342-17	.358-17	.373-17	.387-17	.398-17	.408-17
136000.	735.29	.308-17	.321-17	.337-17	.353-17	.368-17	.382-17	.393-17	.403-17
136656.	731.76	.526-17	.535-17	.545-17	.556-17	.566-17	.575-17	.582-17	.587-17
150000.	666.67	.515-17	.523-17	.532-17	.542-17	.550-17	.558-17	.564-17	.568-17
150304.	665.32	.626-17	.631-17	.638-17	.644-17	.650-17	.655-17	.659-17	.661-17
180000.	555.56	.531-17	.534-17	.536-17	.539-17	.542-17	.543-17	.544-17	.544-17
200000.	500.00	.433-17	.434-17	.436-17	.437-17	.439-17	.440-17	.440-17	.439-17

TABLE VII. BOUND-FREE ABSORPTION COEFFICIENT OF AIR - 10^{-4} ATM

PRESSURE = 0.0001

cm^{-1}	Å	Temperature - °K 6000	8000	10000	12000	14000	16000	18000	20000
13600.	7352.94	0.	0.	0.	0.	0.	0.	0.	0.
13611.	7347.00	0.7251E-11	0.1073E-08	0.2113E-08	0.7909E-09	0.3251E-09	0.1504E-09	0.7723E-10	0.4106E-10
14300.	6993.01	0.7114E-11	0.1058E-08	0.2093E-08	0.7861E-09	0.3241E-09	0.1504E-09	0.7736E-10	0.4120E-10
14361.	6963.30	0.2082E-10	0.3037E-08	0.5849E-08	0.2173E-08	0.8888E-09	0.4099E-09	0.2099E-09	0.1114E-09
19500.	5128.21	0.1812E-10	0.2681E-08	0.5344E-08	0.2029E-08	0.8459E-09	0.3966E-09	0.2059E-09	0.1106E-09
19563.	5111.69	0.2364E-09	0.3625E-07	0.5228E-07	0.1755E-07	0.6935E-08	0.3209E-08	0.1671E-08	0.9457E-09
20500.	4878.05	0.2432E-09	0.3740E-07	0.5401E-07	0.1817E-07	0.7199E-08	0.3340E-08	0.1743E-08	0.9889E-09
20525.	4872.11	0.8240E-09	0.1220E-06	0.1686E-06	0.5532E-07	0.2158E-07	0.9921E-08	0.5146E-08	0.2918E-08
20593.	4856.02	0.1285E-08	0.1889E-06	0.2591E-06	0.8463E-07	0.3293E-07	0.1511E-07	0.7827E-08	0.4437E-08
21200.	4716.98	0.1270E-08	0.1870E-06	0.2571E-06	0.8413E-07	0.3279E-07	0.1507E-07	0.7820E-08	0.4439E-08
21207.	4715.42	0.2225E-08	0.2768E-06	0.4013E-06	0.1306E-06	0.5003E-07	0.2248E-07	0.1142E-07	0.6272E-08
21800.	4587.16	0.2161E-08	0.2733E-06	0.3922E-06	0.1279E-06	0.4910E-07	0.2211E-07	0.1125E-07	0.6194E-08
21845.	4577.71	0.3001E-08	0.3988E-06	0.5552E-06	0.1793E-06	0.6863E-07	0.3093E-07	0.1577E-07	0.8733E-08
22500.	4444.44	0.2890E-08	0.3740E-06	0.5224E-06	0.1692E-06	0.6493E-07	0.2932E-07	0.1497E-07	0.8307E-08
22545.	4435.57	0.5626E-08	0.7287E-06	0.9721E-06	0.3039E-06	0.1175E-06	0.5287E-07	0.2696E-07	0.1532E-07
23200.	4310.34	0.5114E-08	0.6639E-06	0.8894E-06	0.2835E-06	0.1081E-06	0.4873E-07	0.2489E-07	0.1388E-07
23210.	4308.49	0.6986E-08	0.8259E-06	0.1125E-05	0.3562E-06	0.1343E-06	0.5977E-07	0.3017E-07	0.1654E-07
23700.	4219.41	0.6479E-08	0.7682E-06	0.1049E-05	0.3328E-06	0.1257E-06	0.5605E-07	0.2833E-07	0.1555E-07
23763.	4208.22	0.6586E-08	0.7929E-06	0.1079E-05	0.3418E-06	0.1290E-06	0.5751E-07	0.2907E-07	0.1596E-07
31100.	3215.43	0.3103E-08	0.3865E-06	0.5354E-06	0.1736E-06	0.6703E-07	0.3053E-07	0.1574E-07	0.8812E-08
31165.	3208.73	0.5302E-08	0.5579E-06	0.6968E-06	0.2130E-06	0.8068E-07	0.3609E-07	0.1837E-07	0.1021E-07
33000.	3030.30	0.5067E-08	0.5275E-06	0.6532E-06	0.2010E-06	0.7543E-07	0.3378E-07	0.1722E-07	0.9593E-08
33042.	3026.45	0.5520E-08	0.5494E-06	0.6758E-06	0.2066E-06	0.7715E-07	0.3443E-07	0.1751E-07	0.9727E-08
34000.	2941.18	0.5405E-08	0.5341E-06	0.6541E-06	0.1996E-06	0.7452E-07	0.3326E-07	0.1693E-07	0.9413E-08
34026.	2938.93	0.4432E-07	0.3097E-05	0.2842E-05	0.7262E-06	0.2406E-06	0.9878E-07	0.4724E-07	0.2517E-07
36000.	2777.78	0.4140E-07	0.2892E-05	0.2653E-05	0.6732E-06	0.2250E-06	0.9250E-07	0.4431E-07	0.2366E-07
36069.	2772.46	0.4294E-07	0.2955E-05	0.2710E-05	0.6915E-06	0.2289E-06	0.9393E-07	0.4492E-07	0.2394E-07
73000.	1369.86	0.1477E-07	0.9949E-06	0.9105E-06	0.2319E-06	0.7700E-07	0.3183E-07	0.1538E-07	0.8308E-08
73360.	1363.14	0.3305E-07	0.2610E-05	0.2560E-05	0.6821E-06	0.2334E-06	0.9856E-07	0.4839E-07	0.2651E-07
88000.	1136.36	0.2519E-07	0.2090E-05	0.2059E-05	0.5502E-06	0.1886E-06	0.7977E-07	0.3924E-07	0.2154E-07

88505.	1129.88	0.9769E-02	0.2464E-01	0.2983E-02	0.1968E-03	0.2488E-04	0.5002E-05	0.1387E-05	0.4846E-06
98000.	1020.41	0.9341E-02	0.2356E-01	0.2852E-02	0.1881E-03	0.2377E-04	0.4775E-05	0.1322E-05	0.4615E-06
98118.	1019.18	0.8777E-01	0.1347E-00	0.1237E-01	0.6859E-03	0.7690E-04	0.1414E-04	0.3651E-05	0.1203E-05
103000.	970.87	0.8495E-01	0.1302E-00	0.1195E-01	0.6620E-03	0.7418E-04	0.1363E-04	0.3518E-05	0.1159E-05
103821.	963.20	0.8881E-01	0.1406E-00	0.1322E-01	0.7467E-03	0.8490E-04	0.1577E-04	0.4107E-05	0.1362E-05
109000.	917.43	0.8432E-01	0.1335E-00	0.1256E-01	0.7093E-03	0.8065E-04	0.1498E-04	0.3901E-05	0.1293E-05
109837.	910.44	0.9794E 00	0.5699E 00	0.4130E-01	0.1853E-02	0.1773E-03	0.2886E-04	0.6801E-05	0.2252E-05
113000.	884.96	0.9815E 00	0.5667E 00	0.4091E-01	0.1828E-02	0.1743E-03	0.2826E-04	0.6640E-05	0.1797E-05
113434.	881.57	0.1035E 01	0.6419E 00	0.4736E-01	0.2165E-02	0.2102E-03	0.3458E-04	0.8212E-05	0.2498E-05
116000.	862.07	0.1029E 01	0.6363E 00	0.4687E-01	0.2139E-02	0.2073E-03	0.3407E-04	0.8082E-05	0.2455E-05
116516.	858.25	0.1028E 01	0.6360E 00	0.4689E-01	0.2143E-02	0.2080E-03	0.3423E-04	0.8131E-05	0.2472E-05
117000.	854.70	0.1025E 01	0.6336E 00	0.4669E-01	0.2137E-02	0.2068E-03	0.3402E-04	0.8077E-05	0.2455E-05
117345.	852.19	0.8904E 01	0.4162E 01	0.1980E-00	0.7121E-02	0.5899E-03	0.8674E-04	0.1890E-04	0.5410E-05
120000.	833.33	0.9095E 01	0.4243E 01	0.2011E-00	0.7211E-02	0.5958E-03	0.8741E-04	0.1901E-04	0.5433E-05
120788.	827.90	0.9117E 01	0.4274E 01	0.2048E-00	0.7428E-02	0.6200E-03	0.9168E-04	0.2006E-04	0.5744E-05
121000.	826.45	0.9174E 01	0.4298E 01	0.2057E-00	0.7454E-02	0.6216E-03	0.9186E-04	0.2008E-04	0.5749E-05
121198.	825.10	0.9187E 01	0.4308E 01	0.2065E-00	0.7499E-02	0.6269E-03	0.9288E-04	0.2036E-04	0.5842E-05
121442.	823.44	0.9199E 01	0.4313E 01	0.2067E-00	0.7504E-02	0.6273E-03	0.9292E-04	0.2037E-04	0.5846E-05
134000.	746.27	0.9133E 01	0.4261E 01	0.2021E-00	0.7280E-02	0.6045E-03	0.8906E-04	0.1943E-04	0.5555E-05
134436.	743.85	0.9133E 01	0.4264E 01	0.2026E-00	0.7311E-02	0.6081E-03	0.8970E-04	0.1959E-04	0.5603E-05
136000.	735.29	0.9043E 01	0.4220E 01	0.2004E-00	0.7224E-02	0.6005E-03	0.8853E-04	0.1932E-04	0.5524E-05
136656.	731.76	0.9602E 01	0.4493E 01	0.2183E-00	0.7939E-02	0.6609E-03	0.9720E-04	0.2113E-04	0.5998E-05
138000.	724.64	0.9514E 01	0.4450E 01	0.2163E-00	0.7864E-02	0.6544E-03	0.9619E-04	0.2090E-04	0.5929E-05
138413.	722.48	0.9493E 01	0.4440E 01	0.2159E-00	0.7847E-02	0.6529E-03	0.9597E-04	0.2086E-04	0.5915E-05
150000.	666.67	0.8728E 01	0.4079E 01	0.1987E-00	0.7219E-02	0.5996E-03	0.8793E-04	0.1906E-04	0.5389E-05
150304.	665.32	0.9011E 01	0.4217E 01	0.2078E-00	0.7580E-02	0.6301E-03	0.9231E-04	0.1798E-04	0.5629E-05
179000.	558.66	0.6555E 01	0.3114E 01	0.1550E-00	0.5669E-02	0.4707E-03	0.6874E-04	0.1482E-04	0.4152E-05
180000.	555.56	0.6576E 01	0.3077E 01	0.1532E-00	0.5603E-02	0.4652E-03	0.6793E-04	0.1465E-04	0.4103E-05
184322.	542.53	0.6245E 01	0.2922E 01	0.1457E-00	0.5330E-02	0.4425E-03	0.6461E-04	0.1393E-04	0.3971E-05
199000.	502.51	0.5208E 01	0.2437E 01	0.1217E-00	0.4455E-02	0.3698E-03	0.5395E-04	0.1162E-04	0.3252E-05
200000.	500.00	0.5143E 01	0.2407E 01	0.1202E-00	0.4430E-02	0.3653E-03	0.5329E-04	0.1148E-04	0.3212E-05

TABLE VIII. BOUND-FREE ABSORPTION COEFFICIENT OF AIR - 10^{-2} ATM

PRESSURE = 0.0100

cm^{-1}	Å	Temperature - °K 6000	8000	10000	12000	14000	16000	18000	20000
13600.	7352.94	0.	0.	0.	0.	0.	0.	0.	0.
13611.	7347.00	0.7922E-11	0.1567E-08	0.2551E-07	0.5304E-07	0.3085E-07	0.1491E-07	0.7706E-08	0.4103E-08
14300.	6993.01	0.7771E-11	0.1545E-08	0.2526E-07	0.5272E-07	0.3076E-07	0.1490E-07	0.7719E-08	0.4117E-08
14361.	6963.30	0.2274E-10	0.4393E-08	0.7061E-07	0.1457E-06	0.8435E-07	0.4062E-07	0.2095E-07	0.1113E-07
19500.	5128.21	0.1980E-10	0.3917E-08	0.6450E-07	0.1361E-06	0.8028E-07	0.3930E-07	0.2055E-07	0.1105E-07
19563.	5111.60	0.2117E-09	0.5507E-07	0.8462E-06	0.1335E-05	0.6711E-06	0.3191E-06	0.1669E-06	0.9453E-07
20500.	4878.05	0.2175E-09	0.5683E-07	0.8758E-06	0.1384E-05	0.6968E-06	0.3321E-06	0.1740E-06	0.9884E-07
20525.	4872.11	0.7282E-09	0.1857E-06	0.2785E-05	0.4254E-05	0.2092E-05	0.9867E-06	0.5139E-06	0.2916E-06
20593.	4856.92	0.1134E-08	0.2877E-06	0.4292E-05	0.6519E-05	0.3193E-05	0.1503E-05	0.7816E-06	0.4435E-06
21200.	4716.98	0.1120E-08	0.2848E-06	0.4258E-05	0.6480E-05	0.3180E-05	0.1499E-05	0.7809E-06	0.4437E-06
21207.	4715.42	0.2163E-08	0.4204E-06	0.5999E-05	0.9596E-05	0.4816E-05	0.2233E-05	0.1140E-05	0.6269E-06
21800.	4587.16	0.2097E-08	0.4107E-06	0.5879E-05	0.9409E-05	0.4727E-05	0.2197E-05	0.1123E-05	0.6191E-06
21845.	4577.71	0.2915E-08	0.6021E-06	0.8593E-05	0.1338E-04	0.6622E-05	0.3074E-05	0.1574E-05	0.8728E-06
22500.	4444.44	0.2726E-08	0.5645E-06	0.8083E-05	0.1262E-04	0.6265E-05	0.2914E-05	0.1495E-05	0.8303E-06
22545.	4435.57	0.5132E-08	0.1105E-05	0.1557E-04	0.2342E-04	0.1136E-04	0.5256E-05	0.2692E-05	0.1501E-05
23200.	4310.34	0.4671E-08	0.1007E-05	0.1423E-04	0.2148E-04	0.1045E-04	0.4844E-05	0.2486E-05	0.1388E-05
23210.	4308.49	0.5716E-08	0.1243E-05	0.1707E-04	0.2635E-04	0.1294E-04	0.5938E-05	0.3012E-05	0.1653E-05
23700.	4219.41	0.6229E-08	0.1156E-05	0.1592E-04	0.2463E-04	0.1212E-04	0.5569E-05	0.2829E-05	0.1554E-05
23763.	4208.22	0.6411E-08	0.1194E-05	0.1641E-04	0.2532E-04	0.1244E-04	0.5715E-05	0.2903E-05	0.1596E-05
31100.	3215.43	0.2739E-08	0.5832E-06	0.8272E-05	0.1295E-04	0.6467E-05	0.3034E-05	0.1571E-05	0.8808E-06
31165.	3208.73	0.4873E-08	0.8444E-06	0.1096E-04	0.1615E-04	0.7792E-05	0.3587E-05	0.1834E-05	0.1020E-05
33000.	3030.30	0.4640E-08	0.7988E-06	0.1031E-04	0.1512E-04	0.7287E-05	0.3357E-05	0.1720E-05	0.9589E-06
33042.	3026.45	0.5135E-08	0.8308E-06	0.1058E-04	0.1550E-04	0.7450E-05	0.3422E-05	0.1748E-05	0.9723E-06
34000.	2941.18	0.5024E-08	0.8078E-06	0.1026E-04	0.1498E-04	0.7197E-05	0.3306E-05	0.1690E-05	0.9409E-06
34026.	2938.93	0.3924E-07	0.4714E-05	0.4669E-04	0.5566E-04	0.2331E-04	0.9824E-05	0.4717E-05	0.2516E-05
36000.	2777.78	0.3665E-07	0.4402E-05	0.4361E-04	0.5201E-04	0.2180E-04	0.9199E-05	0.4425E-05	0.2365E-05
36069.	2772.46	0.3834E-07	0.4493E-05	0.4430E-04	0.5290E-04	0.2217E-04	0.9340E-05	0.4486E-05	0.2393E-05
73000.	1369.86	0.1331E-07	0.1512E-05	0.1480E-04	0.1771E-04	0.7457E-05	0.3165E-05	0.1536E-05	0.8304E-06
73360.	1363.14	0.2939E-07	0.3972E-05	0.4227E-04	0.5249E-04	0.2263E-04	0.9803E-05	0.4833E-05	0.2650E-05
88000.	1136.36	0.2328E-07	0.3181E-05	0.3403E-04	0.4235E-04	0.1829E-04	0.7935E-05	0.3918E-05	0.2153E-05

88505.	1129.88	0.8588E-02	0.3754E-01	0.4968E-01	0.1521E-01	0.2414E-02	0.4975E-03	0.1385E-03	0.4844E-04
98000.	1020.41	0.8213E-02	0.3590E-01	0.4750E-01	0.1454E-01	0.2307E-02	0.4750E-03	0.1321E-03	0.4612E-04
98118.	1019.18	0.7717E-01	0.2053E-00	0.2060E-00	0.5299E-01	0.7461E-02	0.1406E-02	0.3646E-03	0.1202E-03
100000.	970.87	0.7468E-01	0.1985E-00	0.1990E-00	0.5115E-01	0.7197E-02	0.1356E-02	0.3513E-03	0.1158E-03
103821.	963.20	0.7808E-01	0.2142E-00	0.2202E-00	0.5769E-01	0.8238E-02	0.1569E-02	0.4102E-03	0.1361E-03
109000.	917.43	0.7413E-01	0.2034E-00	0.2092E-00	0.5480E-01	0.7825E-02	0.1491E-02	0.3896E-03	0.1293E-03
109837.	910.44	0.1052E 01	0.8410E 00	0.5561E 00	0.1315E-00	0.1700E-01	0.2865E-02	0.6790E-03	0.2051E-03
113000.	884.96	0.1055E 01	0.8358E 00	0.5487E 00	0.1295E-00	0.1670E-01	0.2806E-02	0.6629E-03	0.1996E-03
113434.	881.57	0.1102E 01	0.9506E 00	0.6560E 00	0.1555E-00	0.2018E-01	0.3435E-02	0.8199E-03	0.2497E-03
116000.	862.07	0.1096E 01	0.9421E 00	0.6484E 00	0.1535E-00	0.1991E-01	0.3384E-02	0.8069E-03	0.2454E-03
116516.	858.25	0.1095E 01	0.9416E 00	0.6486E 00	0.1538E-00	0.1998E-01	0.3400E-02	0.8118E-03	0.2471E-03
117000.	854.70	0.1093E 01	0.9380E 00	0.6454E 00	0.1530E-00	0.1986E-01	0.3379E-02	0.8064E-03	0.2454E-03
117345.	852.19	0.8019E 01	0.6314E 01	0.3165E 01	0.5385E 00	0.5703E-01	0.8623E-02	0.1887E-02	0.5408E-03
120000.	833.33	0.8185E 01	0.6439E 01	0.3219E 01	0.5456E 00	0.5760E-01	0.8690E-02	0.1898E-02	0.5430E-03
120788.	827.90	0.8209E 01	0.6484E 01	0.3264E 01	0.5601E 00	0.5990E-01	0.9113E-02	0.2003E-02	0.5742E-03
121000.	826.45	0.8259E 01	0.6521E 01	0.3279E 01	0.5622E 00	0.6006E-01	0.9130E-02	0.2005E-02	0.5746E-03
121198.	825.10	0.8270E 01	0.6535E 01	0.3292E 01	0.5656E 00	0.6057E-01	0.9232E-02	0.2033E-02	0.5839E-03
121442.	823.44	0.8281E 01	0.6543E 01	0.3295E 01	0.5660E 00	0.6061E-01	0.9236E-02	0.2034E-02	0.5843E-03
134000.	746.27	0.8202E 01	0.6467E 01	0.3234E 01	0.5499E 00	0.5842E-01	0.8853E-02	0.1940E-02	0.5552E-03
134436.	743.85	0.8202E 01	0.6472E 01	0.3239E 01	0.5520E 00	0.5876E-01	0.8916E-02	0.1956E-02	0.5600E-03
136000.	735.29	0.8119E 01	0.6405E 01	0.3204E 01	0.5455E 00	0.5802E-01	0.8800E-02	0.1929E-02	0.5522E-03
136656.	731.76	0.8730E 01	0.6803E 01	0.3421E 01	0.5934E 00	0.6376E-01	0.9659E-02	0.2110E-02	0.5995E-03
138000.	724.64	0.8653E 01	0.6739E 01	0.3387E 01	0.5876E 00	0.6313E-01	0.9559E-02	0.2087E-02	0.5926E-03
138413.	722.48	0.8535E 01	0.6724E 01	0.3379E 01	0.5863E 00	0.6299E-01	0.9537E-02	0.2082E-02	0.5913E-03
150000.	666.67	0.7956E 01	0.6173E 01	0.3099E 01	0.5383E 00	0.5782E-01	0.8737E-02	0.1903E-02	0.5387E-03
150304.	665.32	0.8265E 01	0.6375E 01	0.3208E 01	0.5625E 00	0.6072E-01	0.9171E-02	0.1994E-02	0.5626E-03
179000.	558.66	0.6145E 01	0.4702E 01	0.2368E 01	0.4185E-00	0.4532E-01	0.6828E-02	0.1480E-02	0.4150E-03
180000.	555.56	0.6073E 01	0.4646E 01	0.2340E 01	0.4135E-00	0.4479E-01	0.6748E-02	0.1462E-02	0.4101E-03
184322.	542.53	0.5771E 01	0.4412E 01	0.2222E 01	0.3932E-00	0.4260E-01	0.6418E-02	0.1390E-02	0.3899E-03
199000.	502.51	0.4918E 01	0.3678E 01	0.1853E 01	0.3283E-00	0.3559E-01	0.5359E-02	0.1160E-02	0.3250E-03
200000.	500.00	0.4759E 01	0.3633E 01	0.1830E 01	0.3243E-00	0.3516E-01	0.5294E-02	0.1146E-02	0.3210E-03

TABLE IX. BOUND-FREE ABSORPTION COEFFICIENT OF AIR - 1 ATM

PRESSURE = 1.0000

		Temperature - °K							
cm^{-1}	Å	6000	8000	10000	12000	14000	16000	18000	20000
13600.	7352.94	0.	0.	0.	0.	0.	0.	0.	0.
13611.	7347.00	0.1081E-10	0.1716E-08	0.3672E-07	0.2339E-06	0.6489E-06	0.8306E-06	0.6368E-06	0.3854E-06
14300.	6993.01	0.1061E-10	0.1692E-08	0.3636E-07	0.2384E-06	0.6469E-06	0.8302E-06	0.6378E-06	0.3868E-06
14361.	6963.30	0.3104E-10	0.4810E-08	0.1016E-06	0.6591E-06	0.1774E-05	0.2263E-05	0.1731E-05	0.1046E-05
19500.	5128.21	0.2702E-10	0.4289E-08	0.9286E-07	0.6154E-06	0.1638E-05	0.2189E-05	0.1698E-05	0.1038E-05
19563.	5111.69	0.7417E-10	0.5287E-07	0.1313E-05	0.8242E-05	0.1957E-04	0.2107E-04	0.1465E-04	0.9037E-05
20500.	4878.05	0.7481E-10	0.5452E-07	0.1359E-05	0.8559E-05	0.2036E-04	0.2196E-04	0.1529E-04	0.9451E-05
20525.	4872.11	0.2003E-09	0.1769E-06	0.4338E-05	0.2682E-04	0.6260E-04	0.6615E-04	0.4536E-04	0.2792E-04
20593.	4856.02	0.2999E-09	0.2737E-06	0.6690E-05	0.4123E-04	0.9589E-04	0.1010E-03	0.6906E-04	0.4248E-04
21200.	4716.98	0.2960E-09	0.2710E-06	0.6638E-05	0.4099E-04	0.9552E-04	0.1007E-03	0.6900E-04	0.4250E-04
21207.	4715.42	0.1720E-08	0.4195E-06	0.9144E-05	0.5508E-04	0.1299E-03	0.1417E-03	0.9868E-04	0.5971E-04
21800.	4587.16	0.1645E-08	0.4093E-06	0.8967E-05	0.5415E-04	0.1279E-03	0.1395E-03	0.9730E-04	0.5897E-04
21845.	4577.71	0.1846E-08	0.5911E-06	0.1320E-04	0.7941E-04	0.1853E-03	0.1987E-03	0.1372E-03	0.8329E-04
22500.	4444.44	0.1734E-08	0.5543E-06	0.1242E-04	0.7490E-04	0.1752E-03	0.1884E-03	0.1303E-03	0.7922E-04
22545.	4435.57	0.2325E-08	0.1068E-05	0.2410E-04	0.1436E-03	0.3295E-03	0.3465E-03	0.2363E-03	0.1435E-03
23200.	4310.34	0.2152E-08	0.9731E-06	0.2202E-04	0.1315E-03	0.3026E-03	0.3191E-03	0.2181E-03	0.1327E-03
23210.	4308.49	0.4742E-08	0.1232E-05	0.2611E-04	0.1536E-03	0.3550E-03	0.3800E-03	0.2616E-03	0.1576E-03
23700.	4219.41	0.4585E-08	0.1146E-05	0.2435E-04	0.1435E-03	0.3323E-03	0.3564E-03	0.2457E-03	0.1482E-03
23763.	4208.22	0.4630E-08	0.1182E-05	0.2512E-04	0.1479E-03	0.3421E-03	0.3662E-03	0.2522E-03	0.1521E-03
31100.	3215.43	0.1932E-08	0.5734E-06	0.1270E-04	0.7678E-04	0.1809E-03	0.1962E-03	0.1369E-03	0.8435E-04
31165.	3208.73	0.2407E-08	0.8214E-06	0.1690E-04	0.9714E-04	0.2203E-03	0.2335E-03	0.1602E-03	0.9742E-04
33000.	3030.30	0.2202E-08	0.7757E-06	0.1591E-04	0.9129E-04	0.2074E-03	0.2190E-03	0.1503E-03	0.9157E-04
33042.	3026.45	0.2879E-08	0.8108E-06	0.1630E-04	0.9298E-04	0.2108E-03	0.2226E-03	0.1527E-03	0.9283E-04
34000.	2941.18	0.2794E-08	0.7879E-06	0.1580E-04	0.9000E-04	0.2039E-03	0.2152E-03	0.1477E-03	0.8984E-04
34026.	2938.93	0.1120E-07	0.4498E-05	0.7266E-04	0.3488E-03	0.6916E-03	0.6552E-03	0.4156E-03	0.2408E-03
36000.	2777.78	0.1045E-07	0.4199E-05	0.6787E-04	0.3261E-03	0.6473E-03	0.6139E-03	0.3899E-03	0.2263E-03
36069.	2772.46	0.1275E-07	0.4299E-05	0.6887E-04	0.3301E-03	0.6551E-03	0.6217E-03	0.3949E-03	0.2289E-03
73000.	1369.86	0.5175E-08	0.1451E-05	0.2298E-04	0.1101E-03	0.2197E-03	0.2104E-03	0.1352E-03	0.7945E-04
73360.	1363.14	0.9125E-08	0.3788E-05	0.6585E-04	0.3314E-03	0.6788E-03	0.6585E-03	0.4270E-03	0.2538E-03
88000.	1136.36	0.7174E-08	0.3033E-05	0.5302E-04	0.2676E-03	0.5490E-03	0.5333E-03	0.3463E-03	0.2062E-03

88505.	1129.38	0.2110E-02	0.3565E-01	0.7752E-01	0.9673E-01	0.7305E-01	0.3358E-01	0.1226E-01	0.4641E-02
98000.	1020.41	0.2018E-02	0.3409E-01	0.7412E-01	0.9247E-01	0.6980E-01	0.3206E-01	0.1169E-01	0.4420E-02
98118.	1019.18	0.1836E-01	0.1950E-00	0.3215E-00	0.3371E-00	0.2258E-00	0.9491E-01	0.3227E-01	0.1152E-01
103000.	976.87	0.1835E-01	0.1885E-00	0.3106E-00	0.3254E-00	0.2178E-00	0.9151E-01	0.3110E-01	0.1110E-01
103821.	963.20	0.1918E-01	0.2034E-00	0.3437E-00	0.3670E-00	0.2493E-00	0.1059E-00	0.3630E-01	0.1304E-01
109000.	917.43	0.1321E-01	0.1932E-00	0.3264E-00	0.3486E-00	0.2368E-00	0.1006E-00	0.3449E-01	0.1239E-01
109837.	910.44	0.1353E 01	0.8914E 00	0.8259E 00	0.6956E 00	0.4298E-00	0.1772E-00	0.5840E-01	0.1951E-01
113000.	884.96	0.1361E 01	0.8871E 00	0.8141E 00	0.6818E 00	0.4201E-00	0.1731E-00	0.5696E-01	0.1898E-01
113434.	881.57	0.1372E 01	0.9960E 00	0.9815E 00	0.8472E 00	0.5255E 00	0.2155E-00	0.7086E-01	0.2378E-01
116000.	862.07	0.1367E 01	0.9877E 00	0.9697E 00	0.8352E 00	0.5175E 00	0.2121E-00	0.6971E-01	0.2337E-01
116516.	858.25	0.1366E 01	0.9872E 00	0.9701E 00	0.8364E 00	0.5189E 00	0.2130E-00	0.7012E-01	0.2353E-01
117000.	854.70	0.1363E 01	0.9836E 00	0.9651E 00	0.8314E 00	0.5156E 00	0.2116E-00	0.6964E-01	0.2337E-01
117345.	852.19	0.3065E 01	0.6089E 01	0.4898E 01	0.3284E 01	0.1640E 01	0.5656E 00	0.1653E-00	0.5167E-01
120000.	833.33	0.3071E 01	0.6207E 01	0.4982E 01	0.3331E 01	0.1659E 01	0.5703E 00	0.1663E-00	0.5189E-01
120788.	827.90	0.3124E 01	0.6256E 01	0.5046E 01	0.3396E 01	0.1707E 01	0.5939E 00	0.1749E-00	0.5481E-01
121000.	826.45	0.3135E 01	0.6291E 01	0.5070E 01	0.3410E 01	0.1712E 01	0.5951E 00	0.1752E-00	0.5485E-01
121198.	825.10	0.3138E 01	0.6304E 01	0.5090E 01	0.3431E 01	0.1727E 01	0.6019E 00	0.1776E-00	0.5575E-01
121442.	823.44	0.3140E 01	0.6312E 01	0.5096E 01	0.3434E 01	0.1728E 01	0.6023E 00	0.1777E-00	0.5579E-01
134000.	746.27	0.3001E 01	0.6230E 01	0.5004E 01	0.3347E 01	0.1671E 01	0.5781E 00	0.1696E-00	0.5302E-01
134436.	743.85	0.3002E 01	0.6235E 01	0.5012E 01	0.3356E 01	0.1678E 01	0.5816E 00	0.1709E-00	0.5346E-01
136000.	735.29	0.2964E 01	0.6170E 01	0.4957E 01	0.3317E 01	0.1657E 01	0.5740E 00	0.1686E-00	0.5271E-01
136656.	731.76	0.3798E 01	0.6606E 01	0.5269E 01	0.3534E 01	0.1778E 01	0.6218E 00	0.1835E-00	0.5716E-01
138000.	724.64	0.3783E 01	0.6545E 01	0.5216E 01	0.3496E 01	0.1759E 01	0.6150E 00	0.1814E-00	0.5650E-01
138413.	722.48	0.3778E 01	0.6531E 01	0.5204E 01	0.3488E 01	0.1754E 01	0.6136E 00	0.1810E-00	0.5637E-01
150000.	666.67	0.3574E 01	0.6034E 01	0.4768E 01	0.3189E 01	0.1603E 01	0.5605E 00	0.1653E-00	0.5134E-01
150304.	665.32	0.3996E 01	0.6225E 01	0.4926E 01	0.3299E 01	0.1664E 01	0.5847E 00	0.1728E-00	0.5359E-01
179000.	558.66	0.3134E 01	0.4611E 01	0.3627E 01	0.2426E 01	0.1225E 01	0.4321E-00	0.1279E-00	0.3950E-01
180000.	555.56	0.3161E 01	0.4557E 01	0.3583E 01	0.2397E 01	0.1211E 01	0.4270E-00	0.1263E-00	0.3903E-01
184322.	542.53	0.3025E 01	0.4329E 01	0.3403E 01	0.2276E 01	0.1150E 01	0.4058E-00	0.1201E-00	0.3711E-01
199000.	502.51	0.2559E 01	0.3612E 01	0.2836E 01	0.1896E 01	0.9584E 00	0.3384E-00	0.1002E-00	0.3093E-01
200000.	500.00	0.2530E 01	0.3568E 01	0.2801E 01	0.1873E 01	0.9465E 00	0.3343E-00	0.9896E-01	0.3055E-01

TABLE X. BOUND-FREE ABSORPTION COEFFICIENT OF AIR - 10^2 ATM

PRESSURE = 100.0000

cm^{-1}	Å	Temperature - °K 6000	8000	10000	12000	14000	16000	18000	20000
13600.	7352.94	0.	0.	0.	0.	0.	0.	0.	0.
13611.	7347.00	0.8866E-11	0.2206E-08	0.4301E-07	0.2918E-06	0.1116E-05	0.2806E-05	0.5129E-05	0.7179E-05
14300.	6993.01	0.8598E-11	0.2175E-08	0.4259E-07	0.2900E-06	0.1113E-05	0.2804E-05	0.5137E-05	0.7204E-05
14361.	6963.30	0.2546E-10	0.6183E-08	0.1190E-06	0.8015E-06	0.3051E-05	0.7645E-05	0.1394E-04	0.1948E-04
19500.	5128.21	0.2216E-10	0.5513E-08	0.1087E-06	0.7484E-06	0.2904E-05	0.7395E-05	0.1368E-04	0.1934E-04
19563.	5111.69	0.2741E-10	0.1936E-07	0.1055E-05	0.9836E-05	0.3857E-04	0.9347E-04	0.1613E-03	0.2134E-03
20500.	4878.05	0.2680E-10	0.1969E-07	0.1090E-05	0.1021E-04	0.4017E-04	0.9757E-04	0.1687E-03	0.2236E-03
20525.	4872.11	0.4077E-10	0.5459E-07	0.3401E-05	0.3197E-04	0.1244E-03	0.2989E-03	0.5115E-03	0.6718E-03
20593.	4856.32	0.5187E-10	0.8219E-07	0.5226E-05	0.4914E-04	0.1909E-03	0.4577E-03	0.7816E-03	0.1025E-02
21200.	4716.98	0.5096E-10	0.8131E-07	0.5185E-05	0.4886E-04	0.1901E-03	0.4566E-03	0.7810E-03	0.1025E-02
21207.	4715.42	0.1219E-08	0.2722E-06	0.8119E-05	0.6599E-04	0.2493E-03	0.5948E-03	0.1020E-02	0.1346E-02
21800.	4587.16	0.1159E-08	0.2620E-06	0.7935E-05	0.6487E-04	0.2457E-03	0.5873E-03	0.1008E-02	0.1332E-02
21845.	4577.71	0.1182E-08	0.3138E-06	0.1122E-04	0.9497E-04	0.3601E-03	0.8571E-03	0.1463E-02	0.1922E-02
22500.	4444.44	0.1113E-08	0.2952E-06	0.1056E-04	0.8958E-04	0.3405E-03	0.8122E-03	0.1389E-02	0.1828E-02
22545.	4435.57	0.1179E-08	0.4416E-06	0.1963E-04	0.1714E-03	0.6484E-03	0.1533E-02	0.2597E-02	0.3388E-02
23200.	4310.34	0.1107E-08	0.4070E-06	0.1796E-04	0.1570E-03	0.5952E-03	0.1410E-02	0.2394E-02	0.3129E-02
23210.	4308.49	0.3396E-08	0.7403E-06	0.2275E-04	0.1838E-03	0.6852E-03	0.1616E-02	0.2745E-02	0.3593E-02
23700.	4219.41	0.3151E-08	0.6886E-06	0.2121E-04	0.1718E-03	0.6416E-03	0.1516E-02	0.2578E-02	0.3379E-02
23763.	4208.22	0.3155E-08	0.6988E-06	0.2181E-04	0.1771E-03	0.6610E-03	0.1560E-02	0.2652E-02	0.3475E-02
31100.	3215.43	0.1261E-08	0.3104E-06	0.1082E-04	0.9183E-04	0.3515E-03	0.8460E-03	0.1461E-02	0.1941E-02
31165.	3208.73	0.1314E-08	0.3811E-06	0.1408E-04	0.1161E-03	0.4315E-03	0.1016E-02	0.1727E-02	0.2265E-02
33000.	3030.30	0.1164E-08	0.3502E-06	0.1319E-04	0.1091E-03	0.4056E-03	0.9557E-03	0.1625E-02	0.2134E-02
33042.	3026.45	0.1718E-08	0.3952E-06	0.1365E-04	0.1111E-03	0.4115E-03	0.9678E-03	0.1644E-02	0.2158E-02
34000.	2941.18	0.1659E-08	0.3811E-06	0.1321E-04	0.1076E-03	0.3982E-03	0.9366E-03	0.1592E-02	0.2090E-02
34026.	2938.93	0.2595E-08	0.1439E-05	0.5732E-04	0.4160E-03	0.1371E-02	0.2942E-02	0.4645E-02	0.5752E-02
36000.	2777.78	0.2414E-08	0.1339E-05	0.5351E-04	0.3889E-03	0.1284E-02	0.2758E-02	0.4363E-02	0.5411E-02
36069.	2772.46	0.4298E-08	0.1467E-05	0.5468E-04	0.3938E-03	0.1297E-02	0.2785E-02	0.4403E-02	0.5460E-02
73000.	1369.86	0.2222E-08	0.5312E-06	0.1837E-04	0.1314E-03	0.4346E-03	0.9413E-03	0.1506E-02	0.1894E-02
73360.	1363.14	0.2662E-08	0.1197E-05	0.5163E-04	0.3950E-03	0.1351E-02	0.2984E-02	0.4832E-02	0.6124E-02
88000.	1136.36	0.2056E-08	0.9530E-06	0.4153E-04	0.3189E-03	0.1093E-02	0.2418E-02	0.3922E-02	0.4979E-02

88505.	1129.88	0.2350E-03	0.1916E-01	0.6014E-01	0.1153E-00	0.1457E-00	0.1530E-00	0.1397E-00	0.1126E-00
98000.	1020.41	0.2247E-03	0.9720E-02	0.5750E-01	0.1102E-00	0.1393E-00	0.1461E-00	0.1332E-00	0.1072E-00
98118.	1019.18	0.2111E-02	0.5559E-01	0.2494E-00	0.4017E-00	0.4505E-00	0.4326E-00	0.3678E-00	0.2795E-00
103000.	970.87	0.2043E-02	0.5374E-01	0.2409E-00	0.3877E-00	0.4345E-00	0.4170E-00	0.3544E-00	0.2693E-00
103821.	963.20	0.2136E-02	0.5799E-01	0.2566E-00	0.4373E-00	0.4973E-00	0.4827E-00	0.4138E-00	0.3164E-00
109000.	917.43	0.2028E-02	0.5507E-01	0.2532E-00	0.4154E-00	0.4724E-00	0.4585E-00	0.3931E-00	0.3005E-00
109837.	910.44	0.1096E 01	0.9526E 00	0.8382E 00	0.8374E 00	0.8044E 00	0.7173E 00	0.5857E 00	0.4332E-00
113000.	884.96	0.1104E 01	0.9561E 00	0.8304E 00	0.9210E 00	0.7847E 00	0.6977E 00	0.5687E 00	0.4202E-00
113434.	881.57	0.1105E 01	0.9371E 00	0.9603E 00	0.1018E 01	0.9950E 00	0.8913E 00	0.7271E 00	0.5365E 00
116000.	862.07	0.1101E 01	0.9824E 00	0.9505E 00	0.1004E 01	0.9793E 00	0.8762E 00	0.7143E 00	0.5268E 00
116516.	858.25	0.1100E 01	0.9818E 00	0.9509E 00	0.1005E 01	0.9816E 00	0.8792E 00	0.7176E 00	0.5298E 00
117000.	854.70	0.1098E 01	0.9797E 00	0.9467E 00	0.9993E 00	0.9751E 00	0.8730E 00	0.7123E 00	0.5258E 00
117345.	852.19	0.1288E 01	0.2435E 01	0.3998E 01	0.3921E 01	0.3219E 01	0.2486E 01	0.1803E 01	0.1213E 01
120000.	833.33	0.1278E 01	0.2460E 01	0.4060E 01	0.3977E 01	[illegible]	0.2509E 01	0.1815E 01	0.1218E 01
120788.	827.92	0.1305E 01	0.2523E 01	0.4135E 01	0.4057E 01	0.3340E 01	0.2588E 01	0.1884E 01	0.1273E 01
121000.	826.45	0.1305E 01	0.2532E 01	0.4154E 01	0.4073E 01	0.3359E 01	0.2594E 01	0.1887E 01	0.1274E 01
121198.	825.10	0.1305E 01	0.2536E 01	0.4170E 01	0.4099E 01	0.3380E 01	0.2625E 01	0.1915E 01	0.1296E 01
121442.	823.44	0.1306E 01	0.2538E 01	0.4174E 01	0.4102E 01	0.3382E 01	0.2627E 01	0.1916E 01	0.1297E 01
134000.	746.27	0.1187E 01	0.2439E 01	0.4081E 01	0.3997E 01	0.3274E 01	0.2526E 01	0.1831E 01	0.1233E 01
134436.	743.85	0.1187E 01	0.2446E 01	0.4091E 01	0.4009E 01	0.3286E 01	0.2538E 01	0.1842E 01	0.1242E 01
136000.	735.29	0.1168E 01	0.2416E 01	0.4045E 01	0.3962E 01	0.3245E 01	0.2504E 01	0.1817E 01	0.1224E 01
136656.	731.76	0.1852E 01	0.2977E 01	0.4411E 01	0.4225E 01	0.3453E 01	0.2666E 01	0.1937E 01	0.1307E 01
138000.	724.64	0.1853E 01	0.2962E 01	0.4370E 01	0.4181E 01	0.3414E 01	0.2635E 01	0.1914E 01	0.1291E 01
138413.	722.48	0.1953E 01	0.2958E 01	0.4361E 01	0.4171E 01	0.3405E 01	0.2628E 01	0.1909E 01	0.1288E 01
150000.	666.67	0.1798E 01	0.2781E 01	0.4014E 01	0.3815E 01	0.3105E 01	0.2391E 01	0.1734E 01	0.1168E 01
150304.	665.32	0.2144E 01	0.3065E 01	0.4199E 01	0.3948E 01	0.3210E 01	0.2473E 01	0.1795E 01	0.1210E 01
179000.	558.66	[illegible]	0.2416E 01	0.3134E 01	0.2905E 01	0.2353E 01	0.1809E 01	0.1312E 01	0.8835E 00
180000.	555.56	0.1795E 01	0.2390E 01	0.3098E 01	0.2870E 01	0.2324E 01	0.1787E 01	0.1296E 01	0.8729E 00
184322.	542.53	0.1726E 01	0.2285E 01	0.2946E 01	0.2726E 01	0.2207E 01	0.1697E 01	0.1230E 01	0.8270E 00
199000.	502.51	0.1474E 01	0.1928E 01	0.2461E 01	0.2271E 01	0.1833E 01	0.1413E 01	0.1024E 01	0.6829E 00
200000.	500.00	0.1458E 01	0.1905E 01	0.2431E 01	0.2243E 01	0.1815E 01	0.1395E 01	0.1011E 01	0.6813E 00

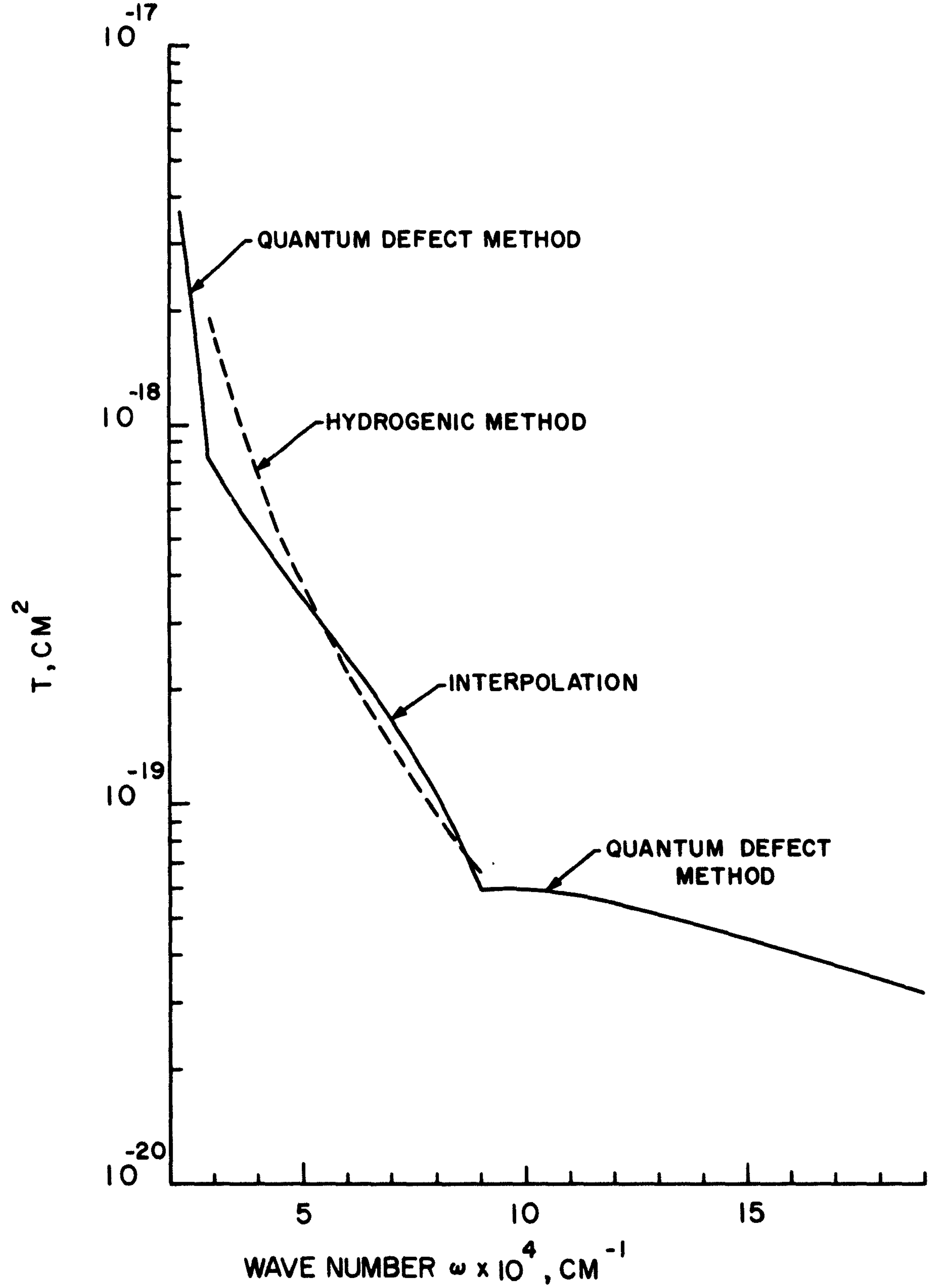

Figure 1. Photoabsorption Cross Section for the 8-1 Transition of N (D wave portion)

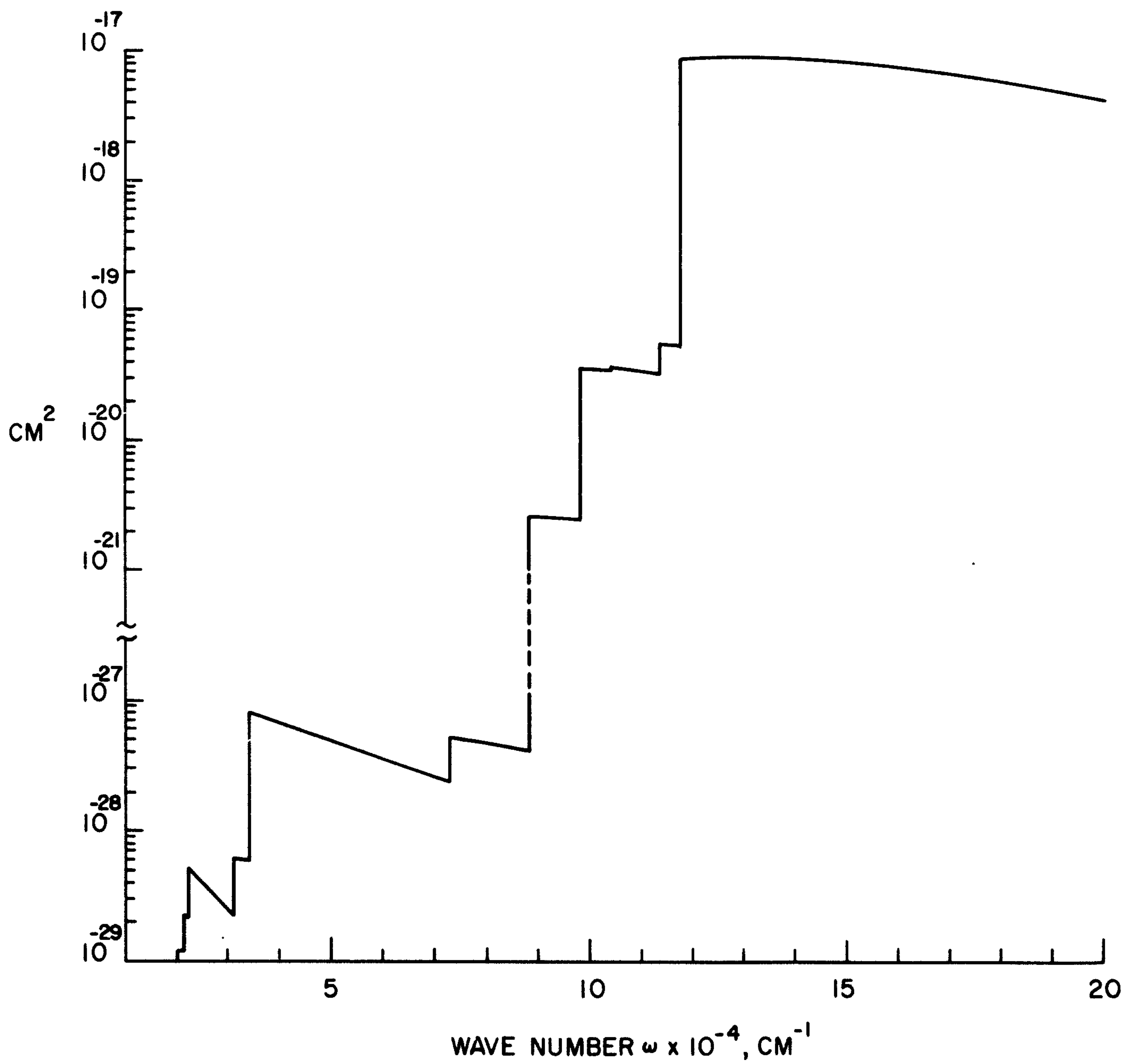

Figure 2. Absorption Coefficient Per Nitrogen Atom - 5000 K

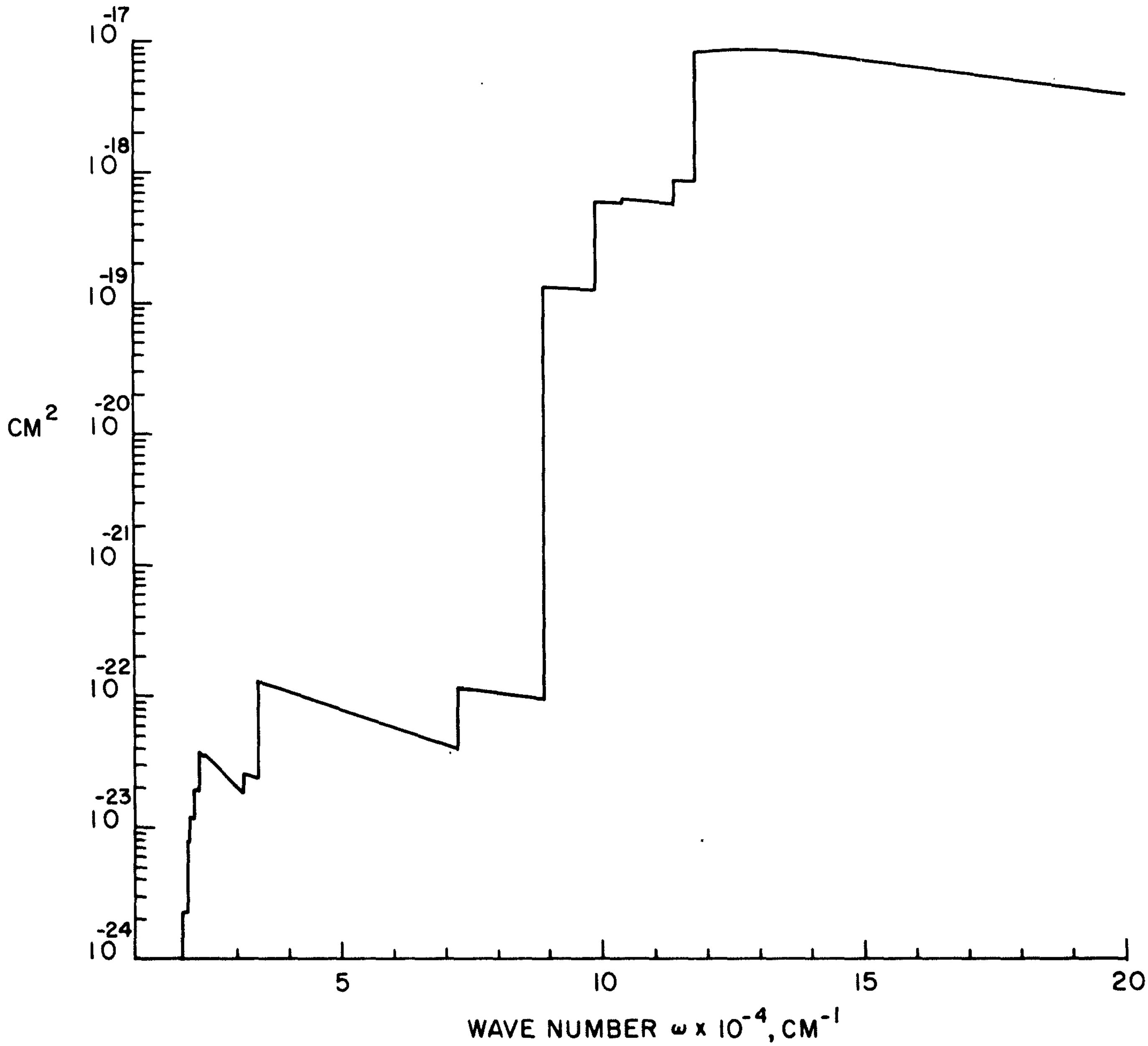

Figure 3. Absorption Coefficient Per Nitrogen Atom - 10,000 K

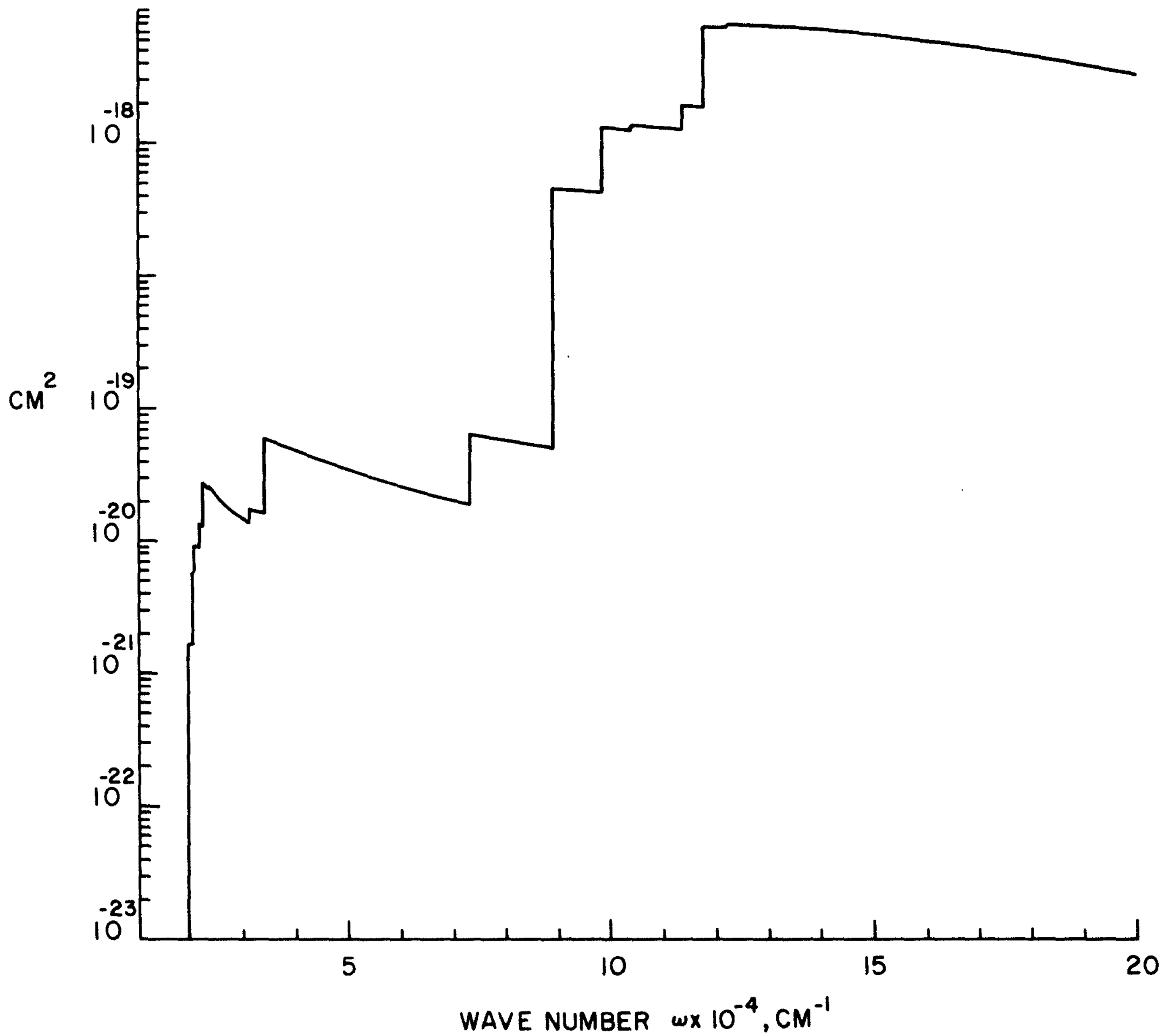

Figure 4. Absorption Coefficient Per Nitrogen Atom - 15,000 K

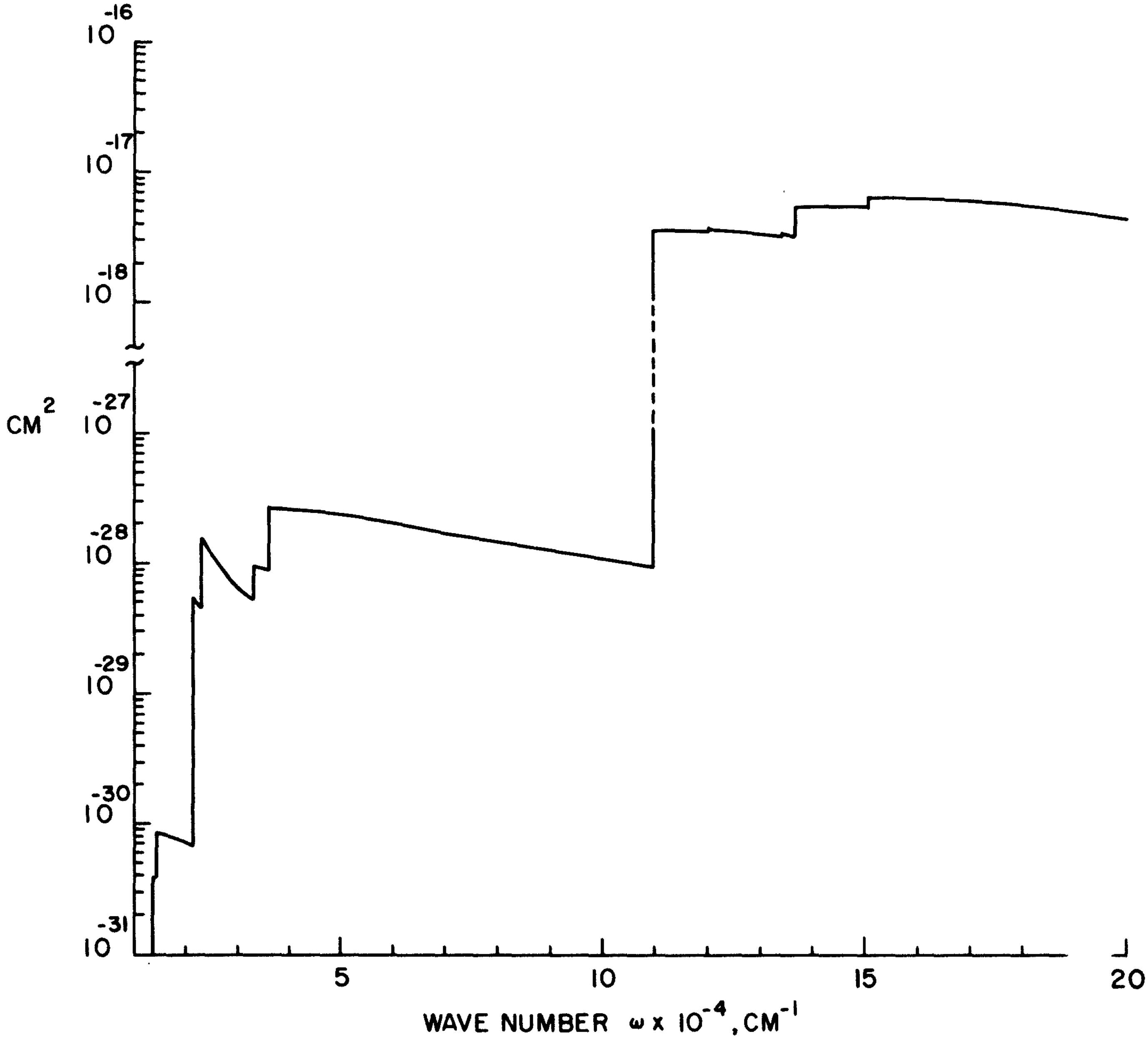

Figure 5. Absorption Coefficient Per Oxygen Atom - 5,000 K

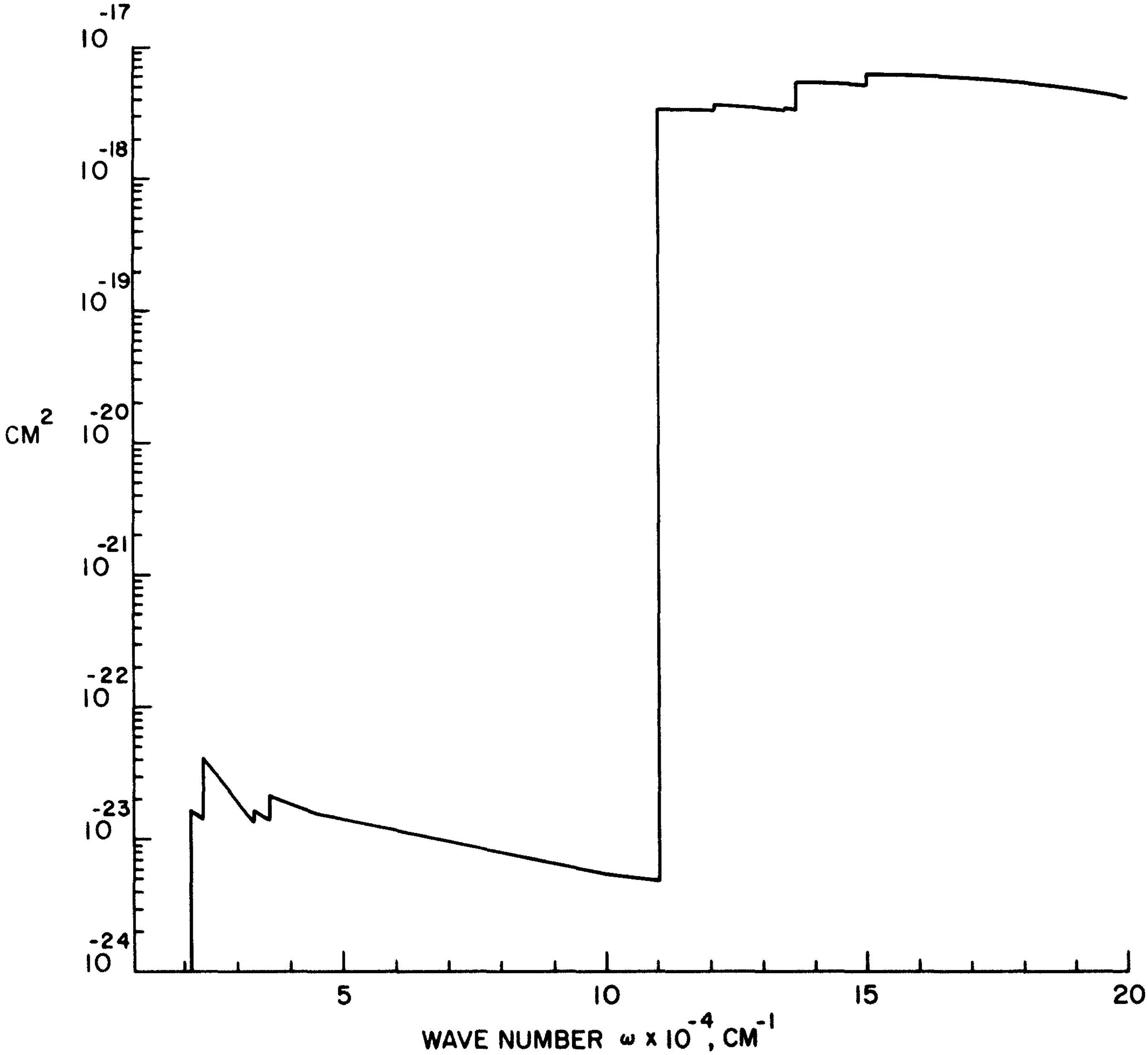

Figure 6. Absorption Coefficient Per Oxygen Atom - 10,000 K

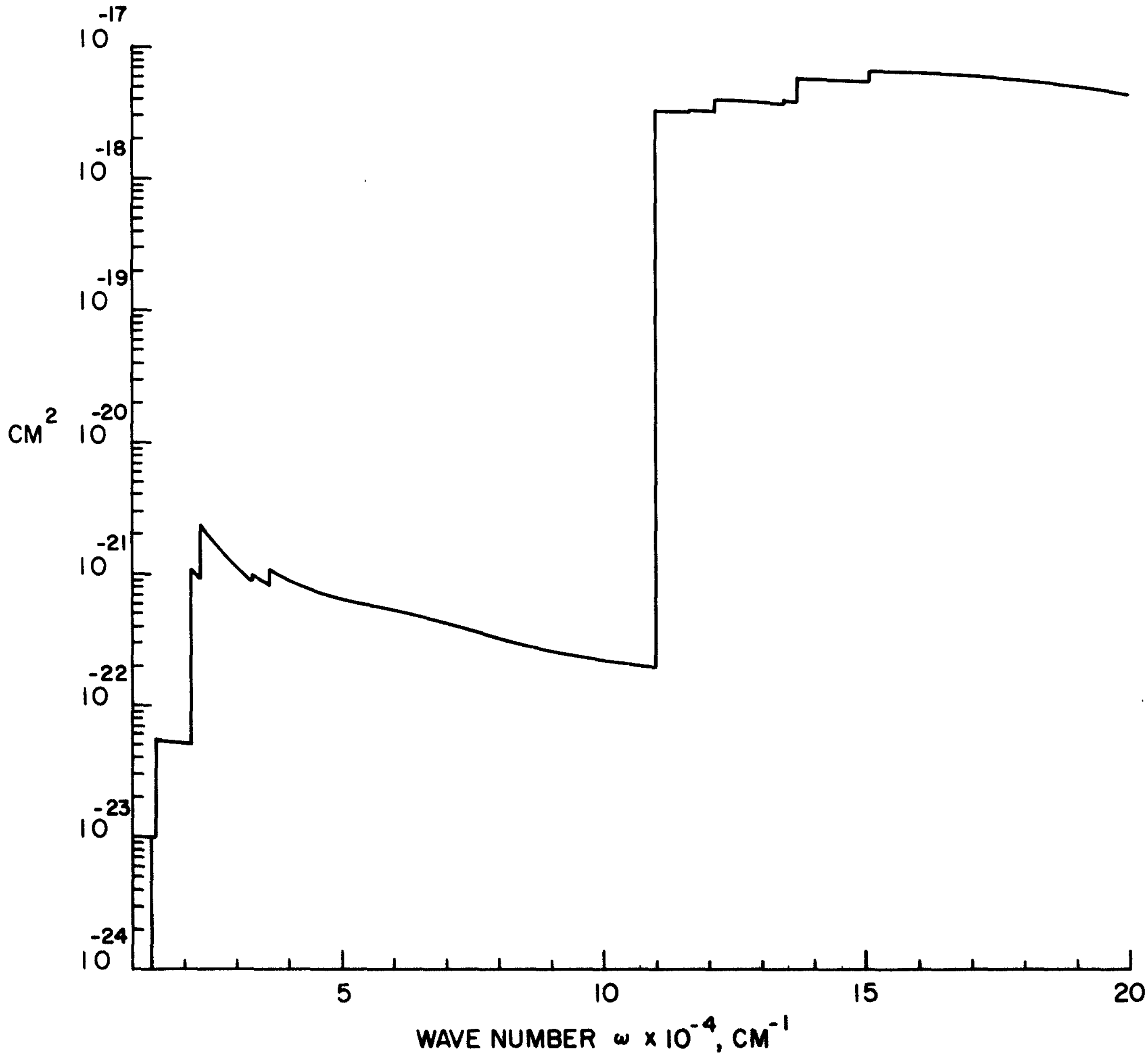

Figure 7. Absorption Coefficient Per Oxygen Atom - 15,000 K

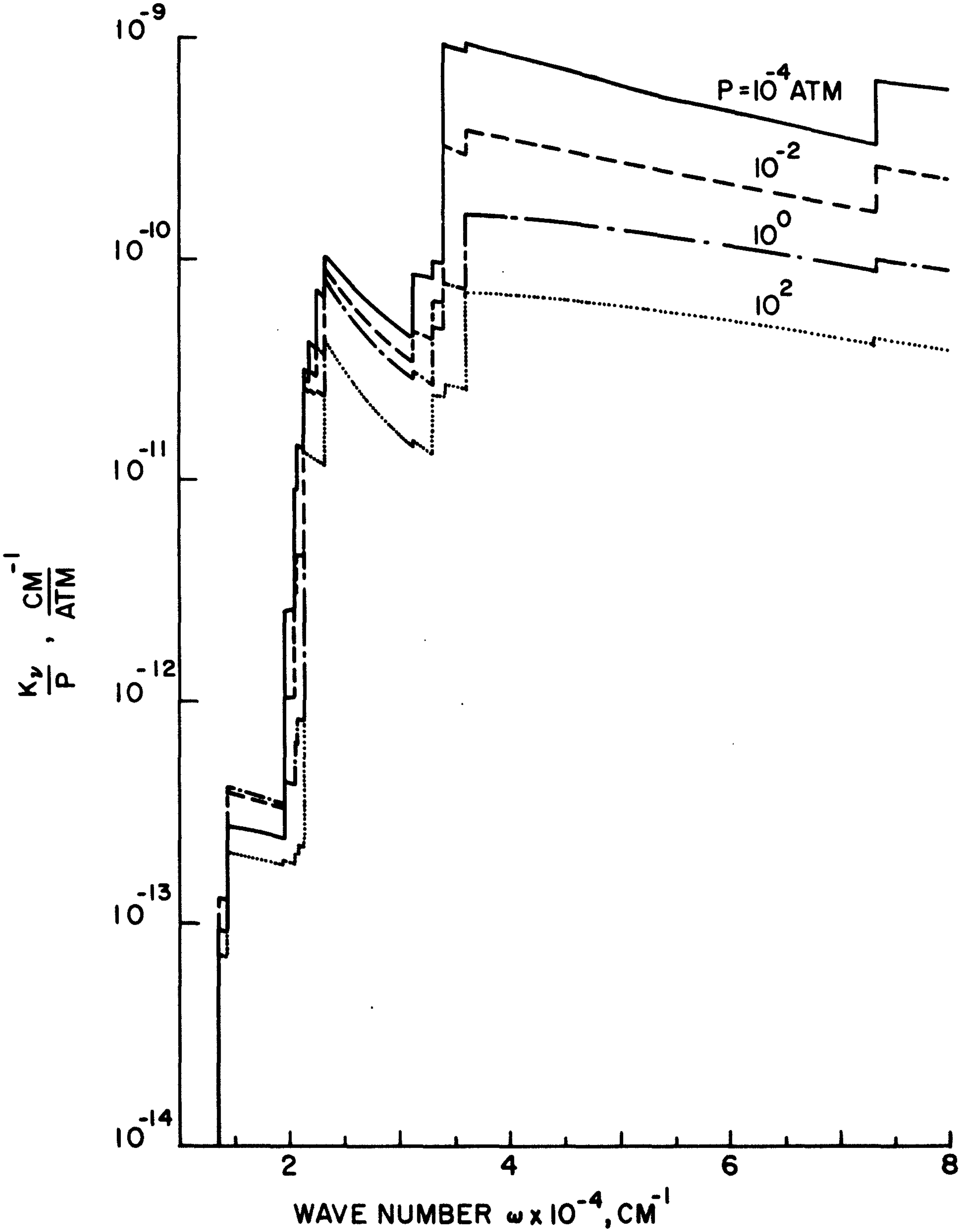

Figure 8. Bound-Free Absorption Coefficient of Equilibrium Air - 5,000 K

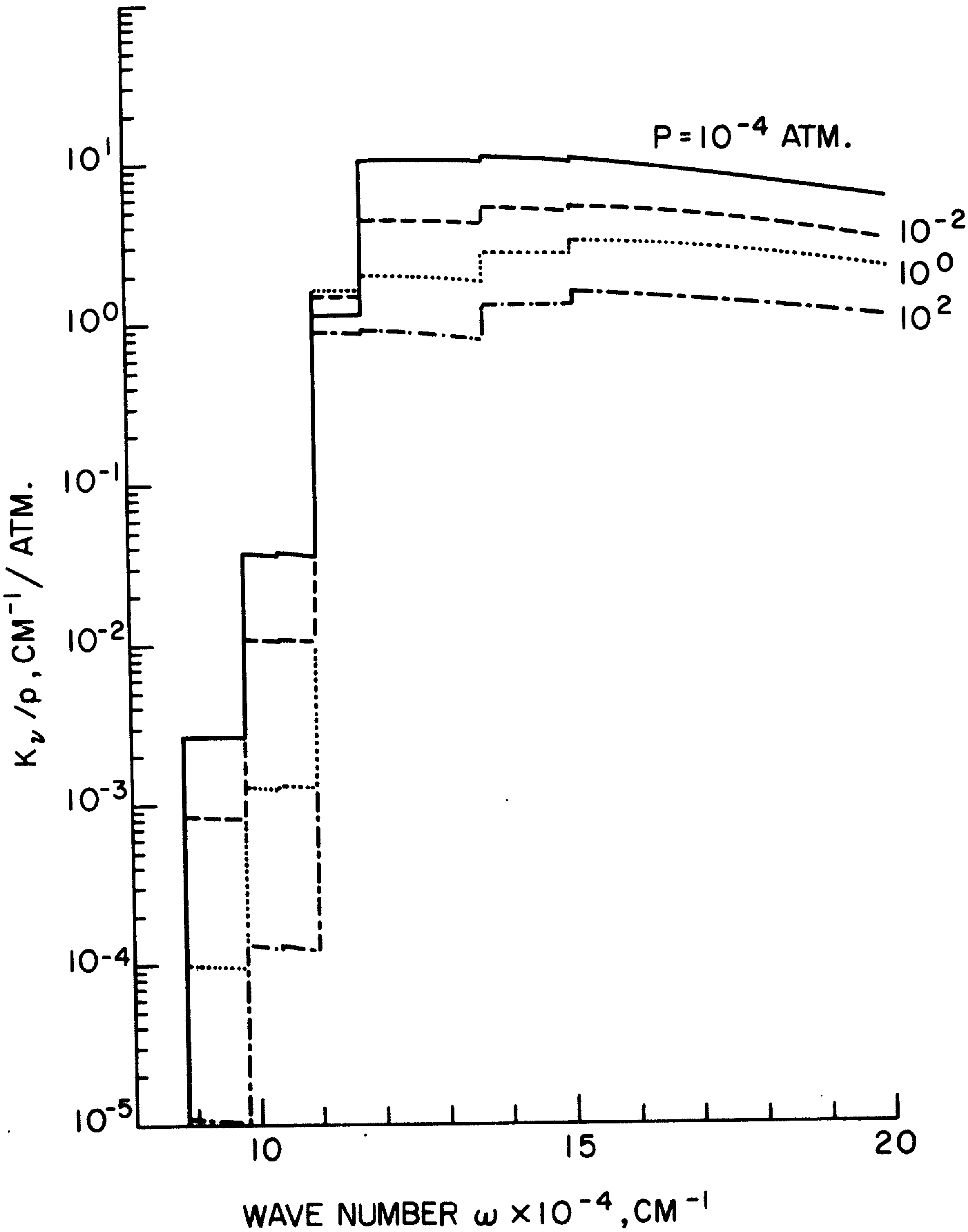

Figure 9. Bound-Free Absorption Coefficient of Equilibrium Air - 5,000 K

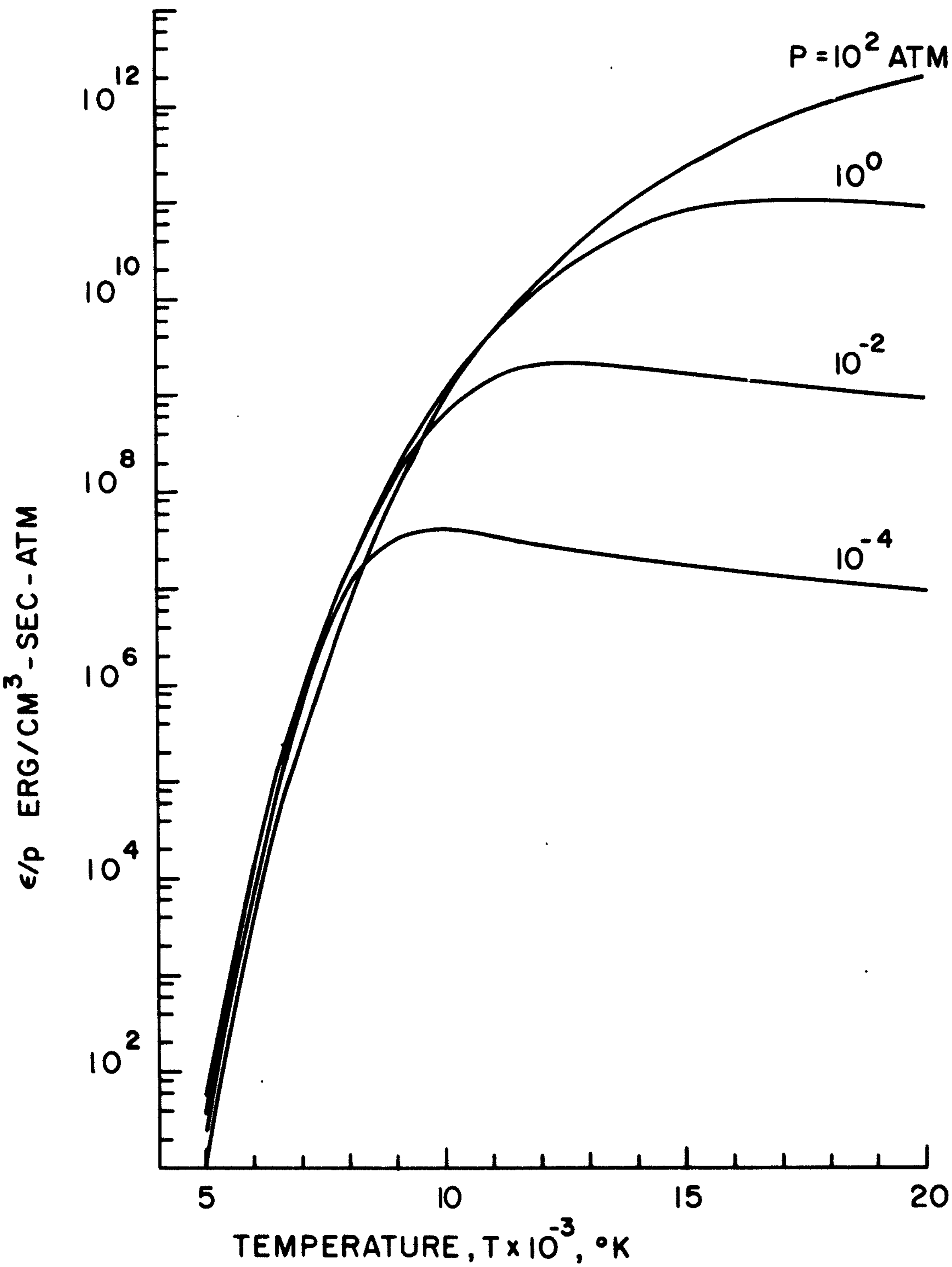

Figure 10. Total Rate of N^+ and O^+ Free-Bound Emission of Equilibrium Air

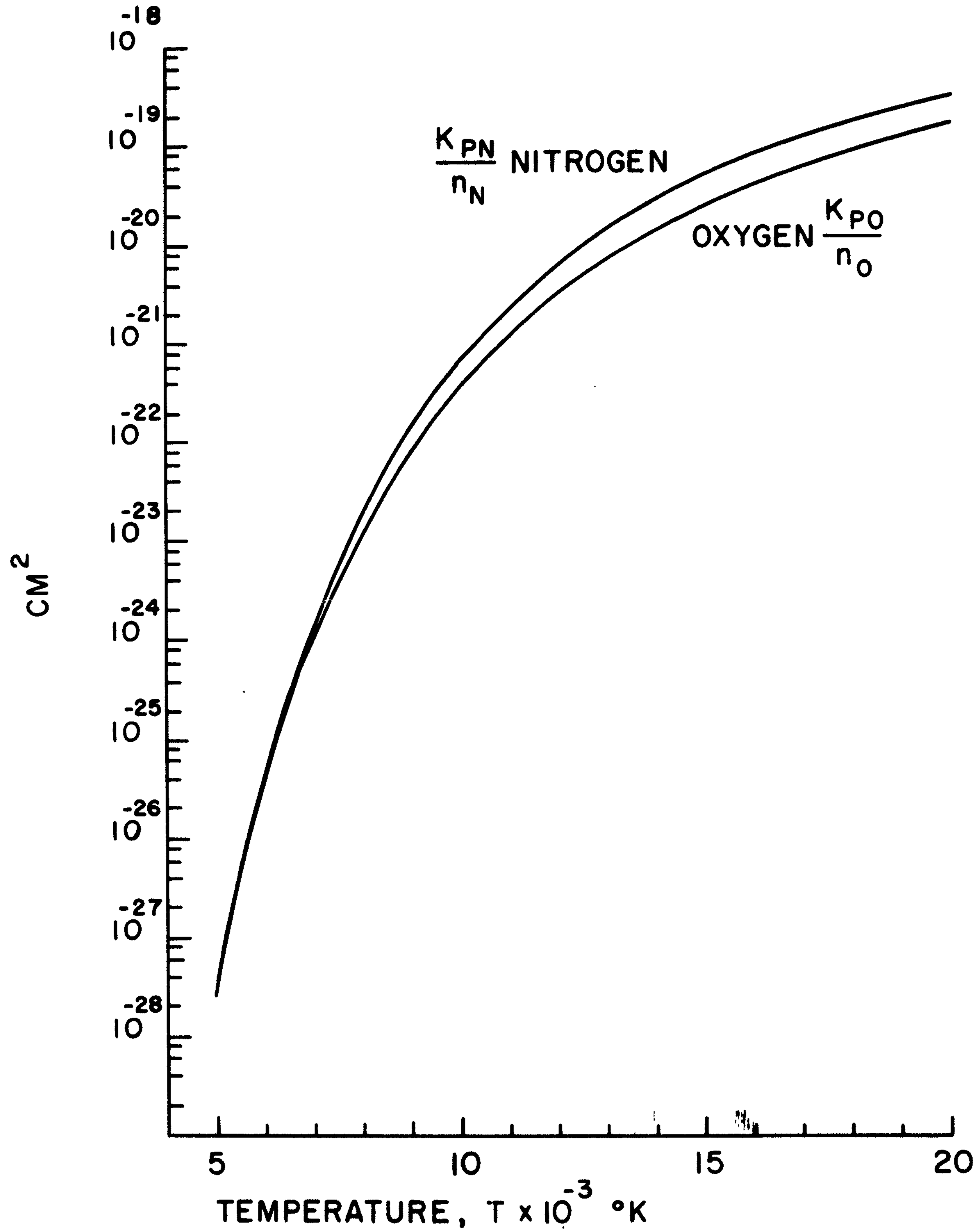

Figure 11. Planck Mean Absorption Coefficient Per Atom of Nitrogen and Oxygen

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SUMMARY

Photoabsorption cross sections for nitrogen and oxygen atoms are computed using the Method of Burgess and Seaton [2]. Results are presented for the radiative recombination of singly ionized nitrogen and oxygen applicable for equilibrium air, for chemical nonequilibrium with internal equilibrium, and internal nonequilibrium.

KEY WORDS

Absorption coefficients, Free-bound radiation

BY CUTTING OUT THIS RECTANGLE AND FOLDING ON THE CENTER LINE THE ABOVE INFORMATION CAN BE FITTED INTO A STANDARD CARD FILE

AUTHOR Martin P. Sherman John L. Kulander

COUNTERSIGNED S. M. Scala

S. M. Scala, Manager
Theoretical Fluid Physics